PUBLIC LIBRARY
DEC 28 1946
DETROIT

Electronic Engineering

INCORPORATING ELECTRONICS, TELEVISION AND SHORT WAVE WORLD

PRINCIPAL CONTENTS

The Industrial Applications of Luminescence
Aids to Stroboscopic Measurement
The Wide-Band Dipole
A.C.E. — The Automatic Computor
Amplitude Modulated Waves (Data Sheet)

2/- DEC., 1946

Paxolin Tubes and Cylinders

Because of their light weight, good mechanical and electrical properties, Paxolin tubes and cylinders were called upon during the war to do many jobs that we had never even thought about.

This meant that they were in short supply for their usual job of helping to keep electricity in its proper place. Supplies are now getting back to normal, and we are always pleased to give full particulars of Paxolin tubes and cylinders to those who would like to know more about their electrical or mechanical properties or both.

THE MICANITE & INSULATORS COMPANY, LTD.

Empire Works, Blackhorse Lane, Walthamstow, London, E.17.

m and i

Manufacturers of MICANITE (Built-up Mica Insulation). Fabricated and Processed MICA, PAXOLIN (Synthetic-resin laminated sheets, rods, tubes, and cylinders). HIGH-VOLTAGE BUSHINGS and TERMINALS for indoor and outdoor use. EMPIRE varnished Insulating Cloths and Tapes and all other forms of Electrical Insulation. Suppliers of Vulcanised Fibre, Leatheroid, Presspahn, etc. Distributors of Micoflex-Duratube Sleevings and Kenutuf Injection Mouldings (P.V.C.).

WHERE HIGH PRECISION CALLS FOR QUICK PRODUCTION

Bullers possess the men and the means to tackle the most exacting job

Made in Three Principal Materials

FREQUELEX
An insulating material of Low Dielectric Loss, for Coil Formers, Aerial Insulators, Valve Holders, etc.

PERMALEX
A High Permittivity Material. For the construction of Condensers of the smallest possible dimensions.

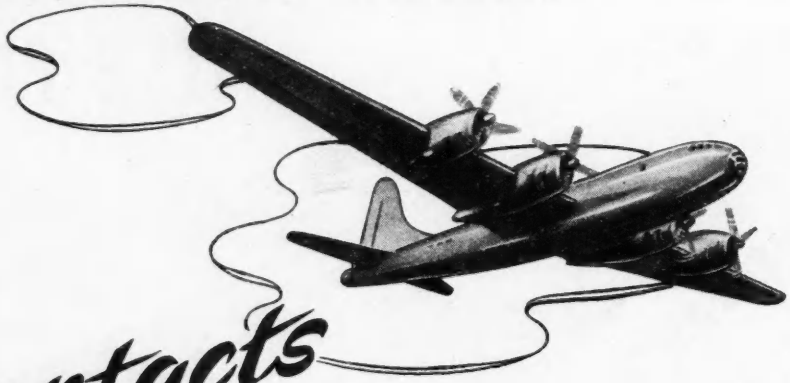
TEMPLEX
A Condenser material of medium permittivity. For the construction of Condensers having a constant capacity at all temperatures.

BULLERS LOW LOSS CERAMICS

BULLERS LTD., 6, LAURENCE POUNTNEY HILL, LONDON, E.C.4
Telephone: Mansion House 9971 (3 lines) Telegrams: "Bullers, Cannon, London"

A

BRIMAR



contacts

DREAMBOAT

TWO-WAY telephony contact with the American Superfortress "DREAMBOAT" before it reached England was made at 18.40 hrs. on Saturday, October 5th, 1946, by Mr. W. T. Pickard (G8KP) of Wakefield, Yorkshire, using BRIMAR VALVES. At the time of the contact "DREAMBOAT" was airborne over Iceland on her non-stop flight from Honolulu via the North Pole to Egypt. Mr. Pickard talked with "DREAMBOAT'S" officer (Frank Shannon) for 17 minutes. To quote Mr. Pickard's words: "Reception both ways was equal to local B.B.C. transmissions."

Another Triumph for

BRIMAR

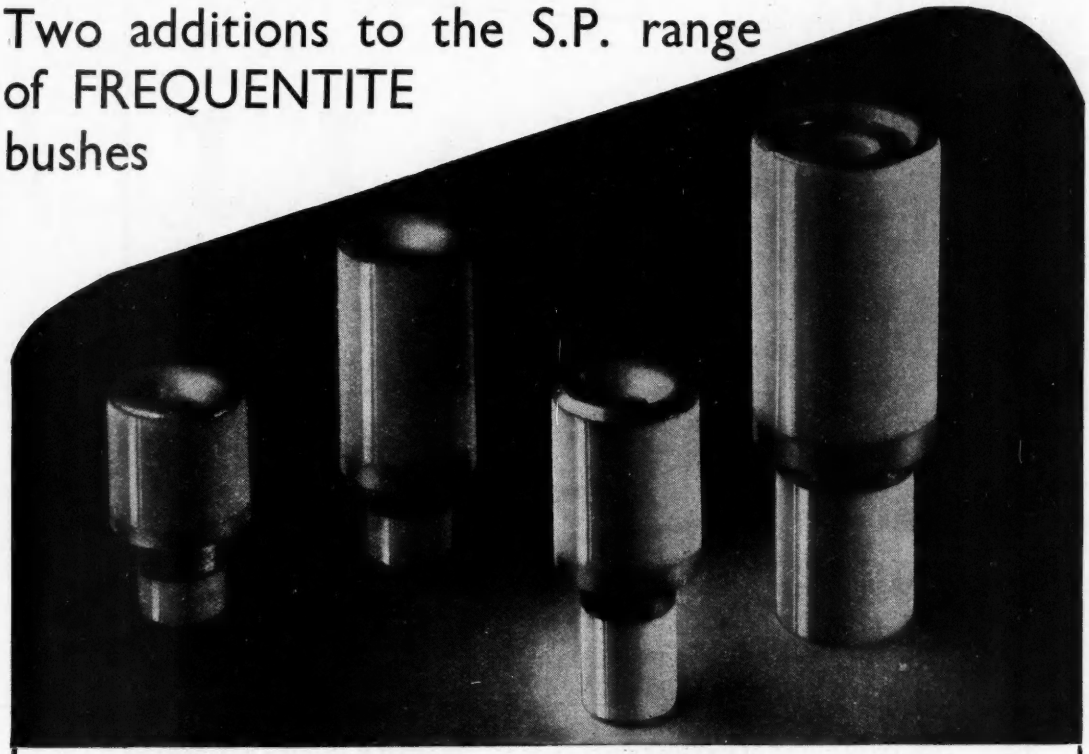
BVA

VALVES

STANDARD TELEPHONES AND CABLES, LIMITED · FOOTSCRAY · KENT

METALLISED CERAMICS

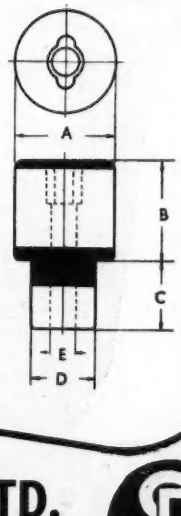
Two additions to the S.P. range of FREQUENTITE bushes



R.50650 R.50764 ★R.50844 ★R.50855

TYPE	A mms.	B mms.	C mms.	D mms.	E mms.
R.50650	9·5	9·5	6·4	6·25	2·75
R.50764	9·5	16·7	6·4	6·25	2·75
★R.50844	9·5	12·7	9·5	6·25	2·75
★R.50855	12·7	22·2	12·7	9·5	3·9

★ Recent additions to the range



For full information and prices please write to :

STEATITE & PORCELAIN PRODUCTS LTD.

STOURPORT ON SEVERN, WORCS. Telephone: Stourport III. Telegrams: Steatain, Stourport.

S.P.43

Insulate with

PERMALI

Laminated, Impregnated, Densified

Outstanding for **STRENGTH**

Conforms to DCD WT1000

designers

Write for Data Booklet 26B, giving electrical and Physical Properties and Mechanical Characteristics of this extremely useful material, to The NEW INSULATION CO. LTD., Gloucester (Eng). Telephone: 4941.

9223

Model 90a

UNIVERSAL TAYLORMETER

First grade accuracy,

40 ranges, 1000 ohms per volt.

1 Four-inch meter scale.

2 Mirror and Knife edge pointer.

3 Buzzer for Continuity Tests.

4 Automatic overload protection.

5 Self Contained Resistance measurements from 1 Ohm up to 1 Megohm.

6 Three Self-contained capacity ranges with external A.C. Supply.

Limited supplies of these instruments are now available. All orders are executed in strict rotation.

Please write for technical brochure.

Price **£15. 15. 0.**

Taylor Electrical Instruments Ltd.

419-424 MONTROSE AVENUE, SLOUGH, BUCKINGHAMSHIRE

Tel: Slough 21381 (4 lines) Grams: "Taylins" Slough

CONSTANT-VOLTAGE A.C. OR D.C.

WESTINGHOUSE

can provide it efficiently and economically.

The "Stabilistor" provides an a.c. voltage of good waveform substantially independent of load current and/or variations in the a.c. supply voltage. It is entirely static, made in outputs of from 4 VA to 1,500 VA, and may be designed for any a.c. input or output voltage. Efficiency about 85%; instantaneous action.

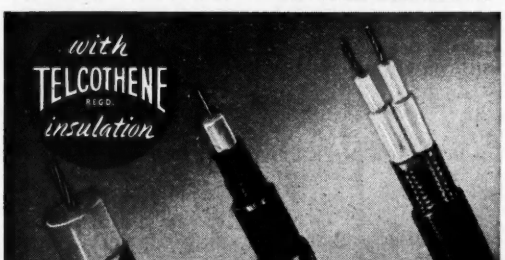
The "Westat" provides a constant-voltage d.c. output for battery charging and provides automatic compensation for the effects of mains fluctuations and load variations. It is designed to "float" across a battery and maintain its voltage within very fine limits. The "Noregg" is a similar equipment, but is for the direct operation of d.c. apparatus from an a.c. supply.

Full descriptive literature is available.

Please write to Dept. E.E.

WESTINGHOUSE BRAKE & SIGNAL Co. Ltd.,
82 York Way, Kings Cross, London, N.1.

TELCON CABLES



Supreme for Radio & Television

A complete range of High Frequency Cables with "TELCOTHENE" low loss insulation, is now available for use in the audio, radio, and electronic fields of application. Write for H.F. brochure.

TELCON designed H.F. Cables are the basis of world standards

THE TELEGRAPH CONSTRUCTION & MAINTENANCE CO. LTD.
Founded 1864.
Head Office: 22 OLD BROAD STREET, LONDON, E.C.2. Tel: LONdon Wall 3141
Enquiries to: TELCON WORKS, GREENWICH, S.E.10. Tel: Greenwich 1040

Electronic Engineering

DECEMBER, 1946

Volume XVIII. No. 226.

CONTENTS

PAGE

Editorial—ENIAC 359

Marine Radar 360

The Industrial Applications of Luminescence
By Dr. W. Sommer 361

Aids to Stroboscopic Measurement
By E. Lloyd Thomas, B.Sc., A.C.G.I. 369

A.C.E. — The Automatic Computing Machine 372

Television Commentary 373

A Neon Stroboscopic Lamp 374

Amplitude Modulated Waves (Data Sheet)
By Hilary Moss, Ph.D., A.M.I.E.E. — ... 375

The Transient Response of a Tuned Circuit
By D. G. Tucker, Ph.D., A.M.I.E.E. 379

The Wide-band Dipole ...
By F. Duerden, B.Sc., A.M.I.E.E. 382

The Ion Trap in C. R. Tubes ... ...
By J. Sharpe, B.Sc. 385

Mass and Energy—A Misconception corrected (Abstracted) 386

Cylindrical Draughting Machines for Electrical Diagrams (Abstracted)
By A. M. Haworth A.M.I.E.E. 387

Book Reviews 388

Correspondence 389

Notes from the Industry 390

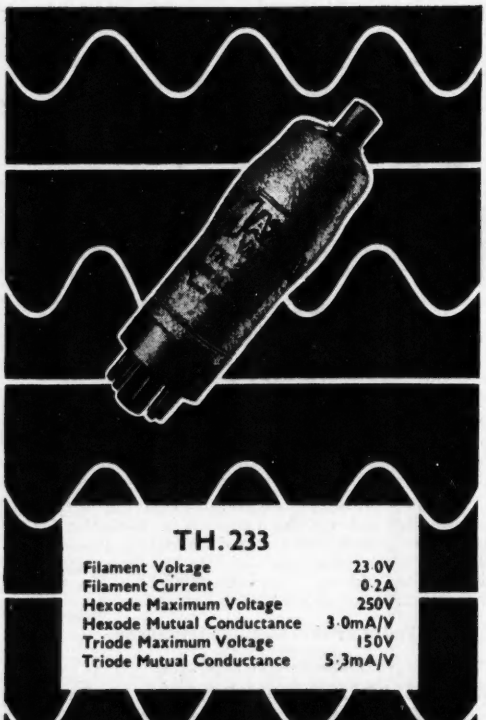
Abstracts of Electronic Literature ... 392

December Meetings xvi

CONDITIONS OF SALE.—This periodical is sold subject to the following conditions, namely, that it shall not, without the written consent of the publishers first given, be lent, re-sold, hired out or otherwise disposed of by way of Trade except at the full retail price of 2/- and that it shall not be lent, re-sold, hired out or otherwise disposed of in a mutilated condition or in any unauthorised cover by way of Trade, or affixed to or as part of any publication or advertising, literary or pictorial matter whatsoever.

TH. 41

Filament Voltage	4·0V
Filament Current	1·3A
Hexode Maximum Voltage	250V
Hexode Mutual Conductance	3.1mA/V
Triode Maximum Voltage	150V
Triode Mutual Conductance	5·3mA/V



TH. 233

Filament Voltage	23·0V
Filament Current	0·2A
Hexode Maximum Voltage	250V
Hexode Mutual Conductance	3·0mA/V
Triode Maximum Voltage	150V
Triode Mutual Conductance	5·3mA/V

The TH.41 designed for use in A.C. Mains Receivers and the TH.233 in AC/DC Receivers, are Triode-Hexode Frequency Changers.

They have been specially designed to meet the requirements of All-Wave Receivers and the inter-action between the input and oscillator circuits has been reduced to a minimum.

A high Conversion Conductance is provided with a large initial grid bias, thus ensuring that no grid current is taken on the Short Wave bands.

The characteristics have been so designed as to provide large signal handling capacity with low cross modulation and low harmonic content.

MAZDA

RADIO VALVES AND CATHODE RAY TUBES

THE EDISON SWAN ELECTRIC CO. LTD., 155, CHARING CROSS ROAD, LONDON, W.C.2

R.M.44

PROPRIETORS :
HULTON PRESS, LTD.

Electronic Engineering

MANAGING EDITOR :
G. PARR.

EDITORIAL, ADVERTISING AND PUBLISHING OFFICES, 43-44, SHOE LANE, LONDON, E.C.4

TELEPHONE
CENTRAL 7400

Monthly (published last day of preceding month) 2/- net. Subscription Rates: Post Paid to any part of the World—6 months, 13/-; 12 months, 26/-. Registered for Transmission by Canadian Magazine Post.

TELEGRAMS
HULTONPRES, LUD
LONDON.

ENIAC

LORD LOUIS MOUNTBATTEN'S speech at the 21st anniversary dinner of the British Institution of Radio Engineers was stimulating and full of interest to those concerned with what might be called the more recondite applications of electronics.

The idea of an apparatus to save the donkey-work of calculating from intricate formulæ has an appeal to every research worker who always wants more time to think. He should be extra pleased at being promised also an apparatus which will save him having to remember, although it is doubtful whether his wife will trust him with letters to post with any more certainty.

It is unfortunate that certain accounts of the speech, with the enthusiasm of the partly-informed, laid stress on the words " electronic brain," as though all our thinking would be done for us in a few years.

What LORD LOUIS said was : " It is now considered possible to evolve an electronic brain which will perform the functions analogous to those at present undertaken by the semi-automatic portion of the human brain," which is an eminently cautious and reasonable statement and does not portend the decay of all thought.

For some time it has been possible to simulate some of the cruder reactions of the brain by electronic means—for example, the pupil reflex action to varying degrees of illumination can be imitated by means of a photo-cell and an iris diaphragm. We have heard of an electronic cockroach which scuttled under cover when a light was turned on, and could even feed itself from a trickle charger.

But so far no one has conceived the apparatus which would type these words on paper, even though it might set them up after they have been originated.

PROF. HARTREE, who is the first British scientist to operate the Electronic Numeral Integrator and Calculator developed at the University of Pennsylvania, states the point clearly in a letter to *The Times** :—

" These machines can only do precisely what they are instructed to do by the operators who set them up. It is true that they can be set up in such a way as to exercise a certain amount of judgment. But it must be clearly understood that the situation in which judgment has to be exercised, the criteria to be applied, the way the results of applying these criteria are to be assessed, and the decisions as to the action to be taken on these results, must all be fully thought out and anticipated in setting up the machine. As I wrote in the article in *Nature*, ' use of the machine is no substitute for the thought of organising the computations, only for the labour in carrying them out."

" It seems to me that the distinction is important, and that the term ' electronic brain ' obscures it, and is misleading in that it ascribes to the machine capabilities that it does not possess ; and this is why I hope use of this term will be avoided in future."

It is better to stick to a term like " Electronic Computer " until the true electronic brain is evolved, if ever.

* November 7th, 1946.

ELECTRONIC ENGINEERING MONOGRAPHS

The fourth Monograph in the series is now ready under the title :

The Gas-filled Triode and its Applications

By

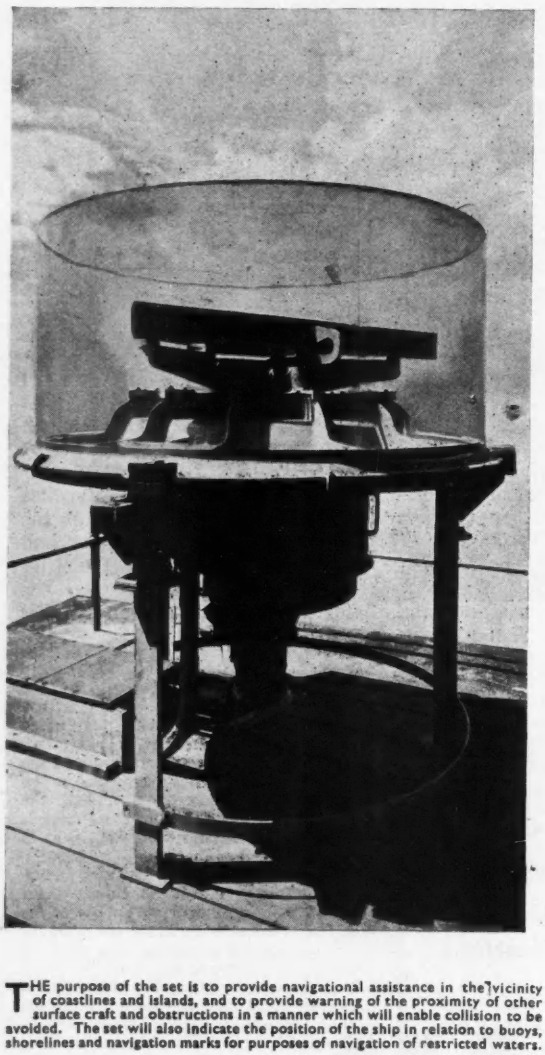
G. WINDRED, A.M.I.E.E.

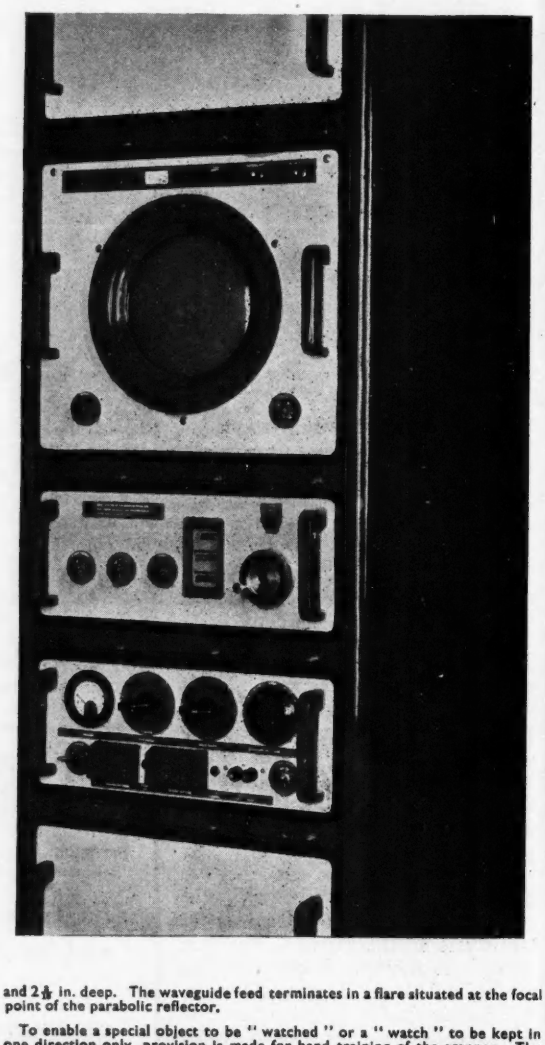
This subject is of interest to all industrial firms who have installed electronic apparatus and to those concerned in its operation and maintenance.

Copies can be obtained from Technical Booksellers, price 2s. 6d., or direct from the Circulation Dept. Hulton Press, 43 Shoe Lane, E.C.4. Price 2s. 8d. post free.

Marine Radar

Equipment manufactured by the Metropolitan-Vickers Electrical Co.





THE purpose of the set is to provide navigational assistance in the vicinity of coastlines and islands, and to provide warning of the proximity of other surface craft and obstructions in a manner which will enable collision to be avoided. The set will also indicate the position of the ship in relation to buoys, shorelines and navigation marks for purposes of navigation of restricted waters.

CONSOLE

The Console unit shown on the right contains the Receiver, Plan Position Indicator (P.P.I), Time Base and Strobe Unit, Control Panel, Power Unit and Modulator, and forms the central unit from which the set is controlled and where the Radar information is presented. Normally it would be mounted in the wheelhouse in an easily accessible position with the P.P.I. screen facing aft

AERIAL UNIT (SCANNER)

This unit, shown on the left, comprises the aerial with its associated waveguides, driving motor, M transmitter, gearing, etc.

The aerial is in the form of a parabolic cheese, 3 ft. 6 in. across the aperture and 2$\frac{1}{8}$ in. deep. The waveguide feed terminates in a flare situated at the focal point of the parabolic reflector.

To enable a special object to be "watched" or a "watch" to be kept in one direction only, provision is made for hand training of the scanner. The speed of rotation of the scanner when manually controlled can be varied from 0 to 4 r.p.m. in either direction.

To relieve the officer of the watch of the need for constant reference to the P.P.I. screen during "Quiet" periods, the automatic warning unit provides an audible warning of the presence of an object in any direction within range limits of 3,000—6,000 yds. The warning is given in the form of a 1,000 c.p.s. "pip" on the loud speaker lasting $\frac{1}{4}$ second during each revolution of the scanner. A soft note initiated by "sea returns" should occur every revolution of the scanner indicating that the set is working properly. The precessing commutator arranges that the 10 deg. sector blanked during reception of "sea returns," occurs in a different direction every revolution so that no area is blanked for more than one revolution at a time. When in areas where many echoes are being received, the warning unit can be switched off.

As stated in the June issue, Messrs. Siemens Bros., Woolwich, are associated with M.-V. in the marketing of this equipment.

The Industrial Applications of Luminescence

By DR. W. SOMMER

ONLY in recent years the application to industry of a certain group of phenomena, termed "Luminescence," has taken place. This achievement is not only due to methodological successes, but also to improvements in the performance of ultra-violet sources. While the research worker in the laboratory has at his command a wide variety of elaborate methods and apparatus, the production engineer will give preference to a set-up which allows of a wide range of applications and uses as simple methods and as robust appliances as possible. The modern forms of the mercury discharge lamp are just the source of radiant energy the engineer has been waiting for; these lamps operate at a high efficiency (38 to 45 and more lumens per watt), have a long life (1,500 hrs.), a high overall power factor (0,75 to 0,98), and are electrically as well as mechanically well fitted for the somewhat rough handling in workshops.

Definitions

The two types of luminescence the practical engineer is most likely to meet, are called phosphorescence and fluorescence, respectively. Although the real nature of the difference between these two phenomena becomes clear only when explained in terms of the Quantum theory, it must suffice here to give the definition based on the effect rather than on its cause, *viz.* :

A substance emitting light after the excitation process has come to an end, is said to show the phenomenon of *phosphorescence.*

A substance emitting light only while the excitation process lasts, is said to show the phenomenon of *fluorescence.*

The *afterglow* is the light emitted by the luminescent substance after the exciting source of radiant energy has been removed or its emission stopped. Thus, for all practical purposes, fluorescence is characterised in that there is no measureable afterglow ($< 10^{-8}$ sec.), while the afterglow of phosphorescent substances has a life from fractions of a second up to many hours, and in some cases even weeks.

The process of absorbing incident radiant energy of a certain wavelength or range of wavelengths is called *excitation.* In 1852, G. G. Stokes' stated that the wavelength of the fluorescence is always greater than that of the exciting radiation. This is known as Stokes' law and holds for practically all substances with the exceptoin of a very few. In 1934, Prilezhaeva[26] found a case of Anti-Stokes behaviour in anilin vapour, the fluorescence frequency of which was 1.1 frequency units greater than the excitation frequency. No satisfying explanation has been proffered yet. Stokes' law is represented in Fig. 1, showing that fluorescence must follow Stokes' law, yet phosphorescence—which also follows it—may "include" the excitation wavelength.

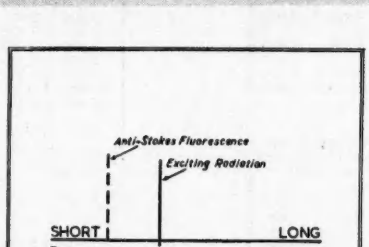


Fig. 1. Diagram to illustrate Stokes' Law.

The exciting radiation can be luminous, ultra-violet, infra-red, or X-rays. Other sources of excitation, although at present of less importance to the production engineer, are cathode-rays, alpha rays, beta rays, friciton, ultrasonic waves, chemical processes, etc.

TABLE I.

Activators and Quenchers.

Phosphor	Impurity				
	Ag	Cu	Mn	Fe	Ni
CaS ...	a	a	a	a	a
SrS ...	a	a	a	–	a
MgS ...	–	–	a	o	o
ZnS ...	a	a	a	q	q
CdS ...	a	a	a	q	q
$CaWO_4$...	–	–	–	q	q
Zn_2SiO_4	–	q	a	q	q
$Cd_2B_2O_5$	o	q	o	q	q

a = activator. –= no effect. q = quencher. o = nothing published up to 1943[3]

Constitution

Synthetic phosphors* are represented by the constitutional formula: $AB + M + F \rightarrow$ Phosphor, where

- *A* may be: barium, beryllium, cadmium, calcium, magnesium, rubidium, sodium, strontium, zinc;
- *B* indicates that one of the following compounds has been formed: borate, carbonate, molybdate, oxide, phosphate, selenide, silicate, sulphide, tungstate;
- *M* is a heavy metal, added as a necessary impurity,[2] *viz.*, antimony, bismuth, cobalt, copper, iron, lead, manganese, nickel, silver, tellurium, tin, uranium, zinc;
- *F* is a flux, *e.g.*, sodium borate, sodium chloride, sodium sulphate.

If the phosphor is of the inorganic type, the solvents *A* and *B* are inorganic and the impurity *M* is metallic, the flux being inorganic likewise. In organic phosphors, the solvents *A* and *B* are organic and so is the flux *F*, but the impurity *M* is either an organic compound or a metal. The phenomenon of luminescence is based on the presence of an impurity *M* which acts as activator, but sometimes has a quenching effect. This is borne out by Table 1.

The absorption and luminescence bands respectively of a phosphor are characteristic not for the type, but only for individual compounds. This is borne out by Table 2 which gives the respective data for *ZnCdS.* The intensity of fluorescence depends, among other factors, on the concentration of the quencher as is shown in Table 3.[3] The relation between the wavelength of the exciting radiation and the excited fluorescence is shown in Fig. 2.

Excitation

As a general rule organic phosphors are best excited by radiation in the near ultra-violet, *i.e.*, at 3,650-63 A.U., and the inorganic phosphors, both synthetic and natural, by the powerful 2,537 A.U. line and by still shorter waves. The various spectral regions from the ultra-violet to the infra-red

* A "phosphor" is a substance exhibiting the phenomenon of luminescence. "Phosphorus" is the name of the chemical element known under the symbol P. In order to avoid ambiguities the phosphor is sometimes called "luminophore."

TABLE 2

Luminescent Colour and Ratio of Mixture.

Per cent. Cd		0	20	40	60	80
Long-wave limit of fundamental absorption ...		3,460	3,720	4,115	4,450	4,820
Peak of fluorescence band-with	Cu	5,200	6,100	6,400	6,600	7,000
	Ag	4.450	4,830	5,100	6,000	6,700

TABLE 3

Intensity of Fluorescence and Concentration of Quencher.

Phosphor	Activator	Quencher conc. %	Fe	Ni	Cu
$ZnSiO_4$ ...	Mn ...	0.00	100	100	100
		0.01	78	78	88
		0.1	30	16	23
$CdSiO_3$ ...	Mn ...	0.00	100	100	100
		0.01	77	90	50
		0.1	15	70	0
$MgWO_4$ ...	— ...	0.00	100	100	100
		0.01	93	100	99
		0.1	83	100	87

TABLE 4

Spectral Ranges.

Range	Name	Action
1,200 to 2,000 A.U.	Schumann rays	ozone forming
2,000 to 2,950 A.U.	far ultra-violet	bactericidal
2,804 to 3,132 A.U.	Dorno region	antirachitic
2,950 to 3,800 A.U.	near ultra-violet	fluorescence
3,800 to 7,600 A.U.	luminous	light, colours
7,600 to 14,000 A.U.	near infra-red	photographic
14,000 to 500.000 A.U.	medium infra-red	heat
500,000 to 4.10^6 A.U.	far infra-red	heat
2,950 to 9.10^5 A.U.	solar radiation reaching the earth.	

TABLE 5 [4]

Luminescent Colour and Excitation Wavelength.

Phosphor	Exciting Wavelength 3,650 A.U.	2,537 A.U.
Cinchophen hydroiodide	strong orange red	dull violet
8-hydroxyquinolene	strong purple	strong violet
Oxyquinolene sulphate	strong crimson	dull purple
Pyrophosphate (ferric)	deep rose	blue

are given in Table 4. Certain phosphors respond to excitation with both 3,650-63 A.U. and 2,537 A.U. ultra-violet, the fluorescent colour in many cases being different, for instance (Table 5). Other substances show no change in colour, for instance, quinine, quinine bisulphate, quinine salicylate.

A wide variety of phosphors respond to still shorter radiation, namely to X-rays which cover the spectral range from 100 A.U. to 0.01 A.U. For most industrial purposes a wavelength of the order of magnitude of 10 A.U. is sufficient and satisfactory. In the following Tables a range of materials is compiled which exhibit the phenomenon of luminescence upon being excited by luminous, ultra-violet, or X-rays. Tables 6 and 7 are so arranged as to show increasing wavelengths in the column marked "emission peak."

Zinc oxide *ZnO*, ordinary salt *NaCl*, potassium bromide *KBr*, potassium iodide *KI*, benzene C_6H_6, and other substances also emit ultra-violet fluorescence. Most of the substances in the above Table emit non-luminous short-wave fluorescence upon irradiation with X-rays. The following, however, do not emit ultra-violet fluorescence upon X-ray excitation, *viz.*, barium chloride $BaCl_2$, beryllium chloride $BeCl_2$, cadmium sulphide *CdS*, and others.

The effect of X-rays of different wavelengths on the intensity of the fluorescence is shown in Fig. 4.

A number of materials exhibit phosphorescence when excited by X-rays or ultra-violet rays (Table 8):

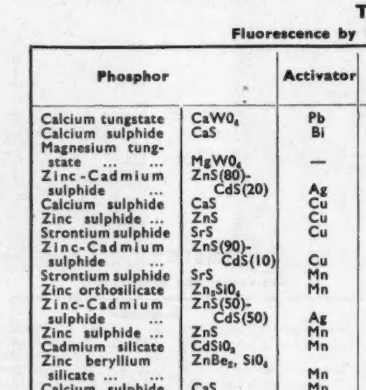


Fig. 2. Relation between excitation wavelength and fluorescence.

Most of these materials exhibit a green fluorescence. Commercially available products are listed in Tables 9 and 10, respectively. Both are excited at 3,650 A.U.

Chemical Notes

The pigment vehicle and solvent of organic or inorganic luminous materials, respectively, must be transparent

TABLE 6 [5,6]

Fluorescence by Ultra-Violet Excitation.

Phosphor		Activator	Excitation long-wave limit, A.U.	Excitation peak A.U.	Emission range A.U.	Emission peak A.U.
Calcium tungstate	$CaWO_4$	Pb	2,900	2,720	3,800-7,000	4,400
Calcium sulphide	CaS	Bi	4,200	3,650		4,750
Magnesium tungstate	$MgWO_4$	—	3,200	2,850	3,800-7,200	4,800
Zinc-Cadmium sulphide ...	ZnS(80)-CdS(20)	Ag		3,650	4,200-5,900	4,880
Calcium sulphide	CaS	Cu	4,200	3,650		5,100
Zinc sulphide ...	ZnS	Cu	4,300	3,300		5,200
Strontium sulphide	SrS	Cu	4,400	3,650		5,350
Zinc-Cadmium sulphide ...	ZnS(90)-CdS(10)	Cu		3,650	4,200-6,500	5,410
Strontium sulphide	SrS	Mn	4,200	3,650		5,550*
Zinc orthosilicate	Zn_2SiO_4	Mn	2,960	2,537	4,500-6,200	5,630
Zinc-Cadmium sulphide ...	ZnS(50)-CdS(50)	Ag		3,650	4,900-7,000	5,690
Zinc sulphide ...	ZnS	Mn	4,500	3,300		5,850
Cadmium silicate	$CdSiO_3$	Mn	3,200	2,400	4,300-7,200	5,950
Zinc beryllium silicate	$ZnBe_2, SiO_4$	Mn	3,000	2,350	4,500-7,200	5,950
Calcium sulphide	CaS	Mn	4,200	3,650		6,000
Cadmium borate	$Cd_2B_2O_4$	Mn	3,600	2,300	4,000-7,200	6,150
Magnesium silicate	$MgSiO_3$	Mn	2,800	2,537	5,000-7,400	6,800
Calcium sulphide	CaS	Ni	4,200	3,650		7,800
Synthetic Dyes						
Alpha-naphthol ...	$C_{10}H_7ON$			4,000	3,900-5,600	4,190
Fluorescein acid...	$C_{20}H_{12}O_5$			3,650	4,500-5,600	4,800
Fluorescein alk. ...	$C_{20}H_{13}O_5$			3,650	5,000-6,000	5,270
Erythrosine ...	$C_{18}H_{11}O_5N_3$			3,650	5,000-6,000	5,600
Eosin G extra ...	$C_{20}H_8O_5Br_4$			3,650	5,400-6,400	5,800
Rhodamine 6G	$C_3H_4ON_2S$			3,650	5,500-7,000	5,800
Magdala Red ...	$C_{30}H_{31}N_4Cl$			3,650	5,500-6,600	5,940
Rhodamine 3B ...				3,650	5,500-7,000	5,950
Rhodamine B extra	$C_3H_4ON_2S$			3,650	5,500-7,000	6,050

* This is the wavelength of maximum sensitivity of the average human eye.

to the exciting radiation (luminous, ultra-violet, or X-rays) and must be stable, which means that neither its chemical nor physical composition is allowed to change under the impact of the exciting radiation. Chemically, the reaction of these substances must be neutral; physically, the optical qualities must not deteriorate, for instance, no discoloration must take place. Suitable vehicles are the cyclohexanone resins, polystyrol, and similar substances. For organic fluorescent materials the writer has used a commercially available solvent of the "acetate" type, and a nitrocellulose medium which both were neutral. These vehicles were found to be very suitable for the acridines, flavines, rhodamines, etc.

Some organic radicals[18] act as activator, others as an inhibitor or quencher of the luminescent phenomenon in organic substances.

Activating radicals are:
amino- $-NH_2$; hydroxy- $-OH$; carboxyl- $-COOH$;

Quenching radicals are:
nitro- $-NO_2$; benzoyl- $-C_6H_5CO-$; acetyl- $-CH_3CO-$.

Among the inhibitors are the bromides, chlorides, some iodides, nitrobenzene $C_6H_5NO_2$; hydroxy-benzene (phenol) C_6H_5OH; methoxy-benzene $C_6H_5OCH_3$; methyl-benzene (toluene) $C_6H_5CH_3$.[4]

Stroboscopic Effect

The electric discharge in a gas or vapour is a process with no thermal inertia. The output of radiation follows the periodicity of the operating current. The mercury discharge lamp is, therefore, a source of flickering light, the flicker having exactly double the frequency of the operating alternating current. Moving objects, seen by the light of a flickering source, show the phenomenon of stroboscopy. Depending upon the duration of the afterglow, luminescent substances may also exhibit the stroboscopic effect, especially when the phosphors are used as coatings in low pressure fluorescent tubular lamps. Taking the stroboscopic effect as 100 per cent, for the electric discharge in mercury and for all phosphors having an afterglow less than 10^{-8} sec., Table 11[7] will represent the stroboscopic characteristic of the various phosphors.

The relative brightness of the above phosphors, when excited under constant and equal conditions is given in Table 12.

The effectiveness of the phosphors is instanced by the figures of Table 13.[8]

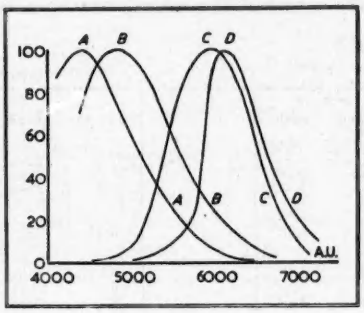


Fig. 3.

Filters

In some cases it will be necessary to use filters. According to the place where the filter is used its spectrum will be different. Fundamentally, there are two places in a set-up where filters are used (Fig. 5). The "short-wave filter" F_s transmits freely the radiation of the source *Ra* necessary to excite the luminescence of the object. The "long-wave filter" F_L is interposed between the luminescent object *L* and the receiver *Re* (observer, photocell, etc.) in order to prevent any short-wave radiation, which might not have been intercepted by the object, from reaching the eye of the observer. A long-wave filter, for instance, must be inserted if the radiation, utilised in producing luminescence, is not entirely confined to the non-luminous region of the spectrum, but extends into the luminous (violet, blue) end. Then a filter glass must be used that does not transmit the non-luminous radiated rays, but allows the eye or photocell to be reached by long radiations only. The F_s filters preferably should be of the heat resisting type. A recommended range of filters is given in Table 14.

If a heat resisting intermediate filter must be used the Aklo type Corning glass 395 with an ultra-violet transmission of 70 per cent. at 3,650 will be of good service.

Light Sources

Low-pressure mercury discharge lamps emit a large proportion of their radiation in the far ultra-violet, mainly at the line 2,537 A.U. (resonance line). It is possible to build lamps which practically emit all their energy on this line. With increasing pressure the number of lines in the mercury spectrum increases and eventually leads to a spectrum of more continuous nature. Lamps with a pressure up to 80 atm. have been built successfully. In Table 15 representative radiation sources are compiled.

In Fig. 6 the relative energy distribution of typical mercury vapour discharge lamps is shown. In order to derive the "relative light emission," *i.e.*, the luminosity (or visibility) of the individual spectral lines, the values of the relative energy distribution must be multiplied by the luminosity factors.[12, 13] The luminosity factors of the mercury spectral lines are given in Table 16.

Photoelectric Cells

Photoelectric cells usually have their peak or peaks of sensitivity in the luminous or infra-red region. A few types, however, are commercially available for the detection of ultra-violet rays (Table 17).

Other cathode materials, affording a long-wave limit in the ultra-violet, are *Pt* (about 1,975 A.U.), *Au* (about 2,500 A.U.), *Ag* (about 2,700 A.U.), *W* (about 2,700 A.U.). All these materials are highly sensitive in the far ultra-violet.

Agreement

Best overall efficiency will be attained when the maximum of the radiation source, filters, luminescent material, and photo-electric cell or human eye or, in general, recording or receiving apparatus, either actually coincide or occur within a narrow band, supposed that the percentage sensitivity remains fairly constant within this range. This means that the 3,650 A.U. radiation is best registered by a caesium oxide cell (for instance the *CMG8* or the *PE7B* (B.T.H., Ltd.)), or any number of the 900 series (R.C.A.) except the rubidium coated 926. The caesium oxide cells have two maxima, one at 3,650 A.U. and the other at about 7,500 A.U. The latter peak can be cancelled by using an appropriate filter, or it may be utilised by using a luminescent material, a few of which emit in the far red. The sensitivity in the ultra-violet can be enhanced by making the bulb from Corex D glass or quartz.[18] If the caesium oxide cell is used in both ranges at once an effect can be obtained as with an intensifying screen (barium platino-cyanide screen) in X-radiology. The ultra-violet energy (3,650 A.U. or less) causes a maximum photocurrent which may still be increased by intercepting with a dark red luminescent material any energy not striking the photocell and causing the dark red luminescence to be "seen" by the photocell, thus causing a further increase of the photocurrent.

TABLE 7

Fluorescence by X-Ray Excitation

Phosphor		Emission: short-wave limit A.U.	Emission: long-wave limit A.U.	Emission: peak A.U.
Fluorspar ...	CaF_2	2,400	3,640	2,840
Willemite...	$ZnSiO_4$	2,270		3,420
Zinc sulphide (synth.) ...	ZnS	3,610		3,800
Lead sulphate	$PbSO_4$	2,660		3,970
Uranium ammonium fluoride ...	$UO_2F_2.3NH_4F$	3,800	4,400	4,100
Zinc sulphate	$ZnSO_4$	3,510		4,260
Scheelite ...	$CaWO_4$	3,750	4,800	4,330
Cadmium phosphate	$Cd_3(PO_4)_2$	3,000		4,440
Quartz ...	SiO_2	3,910		4,480
Cadmium ammonium bromide ...	$CdBr.2NH_4Br$	3,260		4,500
Potassium platino-cyanide ...	$K_2Pt(CN)_4$	4,120	4,900	4,500
Sidot blende	ZnS	4,120	5,090	4,500
Balmain's paint ...	CaS	3,510		4,690
Barium platino-cyanide ...	$BaPt(CN)_4$	4,420	5,090	4,800
Calcium platino-cyanide ...	$CaPt(CN)_4$	4,550	5,090	4,800
Benzoic acid	$C_7H_6O_2$	2,950	4,500	3,900 (min.)
B-naphthol sodium sulphonate		3,300	4,900	3,900
Diphenyl ...	$C_{12}H_{10}$	2,960	5,000	even distrib
Phenol ...	C_6H_6O	2,960	5,000	3,080, 4,850
Naphthalene	$C_{10}H_8$	3,300	4,500	3,460

TABLE 8

Phosphorescent Materials.

Phosphor	Formula	excitation wavelength
Acetamide (techn. grade)	C_2H_5NO	2,537 A.U.
Aluminium acetate ...	$Al(C_2H_3O_2)OH$	2,537 A.U.
Benzoic acid	C_7H_6O	X-rays
Diphenyl	$C_{12}H_{10}$	X-rays
Diphenylamine ...	$C_{12}H_{11}N$	X-rays
Resorcinol	$C_6H_6O_2$	X-rays
Sodium acetate (techn. grade)	$NaC_2H_3O_2$	2,537 A.U.
Theobromine	$C_7H_8O_2N_4$	X-rays
Zinc acetate	$Zn(C_2H_3O_2)_2$	2,537 A.U.
Zinc sulphide	ZnS:Cu	3,650 A.U.
Zinc-Cadmium sulphide	ZnS(82)CdS(18) : Cu	3,650 A.U.

TABLE 9

Commercial Phosphors (Sterling Brand, Made in England).

Type	Dominant wavelength of luminescence A.U.	Luminescent Colour	Afterglow
fluorescent ...	4,600	B	none
	5,150	B-G	none
	5,400	G	none
	5,600	Y	none
	6,000	O	none
	6,300	O-R	none
	6,750	R	none
	7,000	Deep Red	none
phosphorescent	4,400	V	12 hours
	4,500	V	12 hours
	4,800	B-G	12 hours
	5,200	G	4 hours
	5,400	G	4 hours
	5,650	Y	3 hours

TABLE 10

Commercial Phosphors (Cal-Lux Brand, Made in U.S.A.)

Code 36...	Type	Excitation	Range of Luminescence A.U.	Dominant Colour	Rate of Decay
51	phos.	L;C;	4,670 to 6,670	O	slow
2	phos.	L;C;UV;	4,480 to 5,600	B	slow
38-B	phos.	C;	4,210 to 6,600	G	slow
50	fluor.	C;	4,000-5,000; 5,300-6,000	B-White	fast
30-2A	fluor.	C;	4,210 to 6,020	B	$<10^{-6}$ sec.
19-CI	fluor.	C;UV;	4,050 to 6,856	Y-G	fast
19-CI-L	phos.	UV;	4,050 to 6,856	Y-G	slow
16	phos.	C;UV;	5,760 to 6,420	R	<5 sec.
20	fluor.	UV;	4,770 to 6,040	Y-G	fast
33	fluor.	UV;	5,500 to 6,320	Y	fast
34-D	fluor.	UV;	5,890 to 6,500	R	fast
34-DO	fluor.	UV;	5,740 to 6,650	O	fast
6	phos.	L;	5,500 to 6,400	Y	slow

L : luminous rays.
C : cathode rays.
UV : ultra-violet.
SLOW : decay lasts from a few seconds up to 4 to 5 hours.
FAST : decay lasts a few milli-seconds.

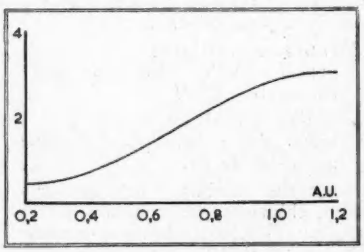


Fig. 4. Relation between X-ray excitation and fluorescence.

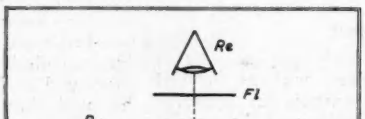


Fig. 5. Arrangement of filters in observing luminescence **(see p. 363).**

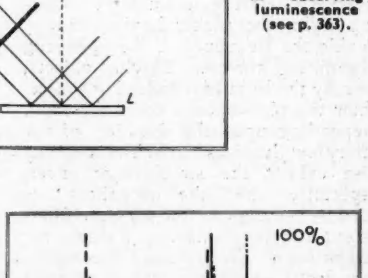


Fig. 6. Relative energy distribution of mercury vapour lamps.

TABLE 11

Stroboscopic Effect.

	Deviation from Mean Light output
	%
Bare Mercury Discharge Lamp	100
Calcium tungstate	90
Magnesium tungstate	35
Zinc silicate	20
Zinc-Beryllium silicate	20

Note : Deviation from mean light output for low wattage tungsten lamps is : 40W.13%, 100W.5%, above 100W. negligible.

TABLE 12

Relative Brightness.

Zinc silicate	100
Magnesium tungstate	63
Calcium tungstate	35
Zinc-Beryllium silicate	33

TABLE 13

Luminous Efficiency.

Phosphor	Lm/W
Zinc silicate	70
Magnesium tungstate	35
Zinc-Beryllium silicate	32
Cadmium silicate	30
Cadmium borate	23
Calcium tungstate	21

TABLE 16

Luminosity of Mercury Lines.

Spectral Band	Principal Line	Luminosity Factor
3,989-4,110	4,047	0,0007
4,110-4,244		0,0014-0,0075
4,284-4,437	4,358	0,0175
4,473-4,650		0,0325-0,0750
4,650-4,838		0,0750-0,162
4,838-5,062	4,916	0,228
5,062-5,319		0,423-0,865
5,319-5,613	5,461	0,98
5,613-5,951	5,770-91	0,89 aver.
5,951-6,353	(6,234),	0,70-0,22 (0,353)

TABLE 18**

Detection Limits of Fluorescence Analysis.

Fluorescent substance	Detectable concentration
Quinine in water	10^{-10}
Uranium in water	10^{-11}
Aesculin	10^{-10}
Anthracene in alcohol**	10^{-10}
Fluorescein	10^{-10}
Eosin	10^{-6}
Saccharine	1.6×10^{-7}
Boric Acid	5.0×10^{-7}
Aluminium	10^{-7}
Arsenic	10^{-7}
Coal tar pitch in asphalt	2.0×10^{-5}
Bromine in hydrochloric acid	10^{-6}
Peroxides	1.2×10^{-5}
Rare earth metals	$(0.5 - 50.0).10^{-6}$

** See footnote on next page.

TABLE 14

Range of Filter Sets.

Short-wave Filter						Long-wave Filter			
Code	transmitted range A.U.	peak at A.U.	%	Maker*	Code	transmitted range A.U.	peak at A.U.	%
597	3,100-4,150	3,650	87	1	1	038	4,100 to l.-R.	5,200-7,200	85
986	2,500-4,250	3,650	75	1	1	368	4,400 to l.-R.	5,200-7,200	85
586	3,300-3,870	3,600	30	1	2	Green	4,500 to l.-R.	5,350	80
584	3,100-3,930	3,590	55	1	2	16Y	4,000 to l.-R.	5,500- . . .	90
14	2,900-4,000	3,650	84	2	3	4	4,500 to l.-R.	5,000	90
18A	3,100-4,000	3,650	55	3	4	401	4,200 to l.-R.	5,600	90
UG1	3,000-4,000	3,650	75	5	4	108	4,600 to l.-R.	5,100	90
UG5	2,300-4,400	2,500	40	5	5	GG5	4,100 to l.-R.	4,600	98
		3,000	95						
		3,250	98		5	GG7	4,500 to l.-R.	5,000	98
		3,650	85						
					5	VG5	4,450 to l.-R.	5,250	90
BG24	1,850-5,500	2,500	66	5					
		3,000	90						
		3,650	98						
		4,000	96						
		4,500	50						

* Makers of Filters
(1) Corning Glass Works, U.S.A.;
(2) Chance Bros., Smethwick, Birmingham, England.;
(3) Wratten, Eastman Kodak, England ; U.S.A.;
(4) Ilford, England.;
(5) Schott & Gen., Jena (Schurmann Corp., U.S.A.).

TABLE 15

Relative U-V Energy Distribution of Radiators.

Type	Pressure	Maker*	below 2,537	2,537	2,537-3,000	3,000-3,341	3,650	luminous
T/M5/369	low	2	—	185,0	0,55	1,26	1,00	4,46
UA27A2, 350 V, 4 A,	low	3	0,122	0,316	0,75	1,06	1,00	2,39
220 V, 3,75 A.,	800 mm.	4	0,475	0,332	0,91	1,08	1,00	2,44
T/M5/155 220 V, 3,75 A. (tilting burner)	high	2	0,110	0,347	0,54	1,04	1,00	2,48
AC UVIARC 600 W. 183 V, 3,92 A,		3	0,338	0,348	0,92	1,07	1,00	2,61
UV I Sun lamp		1	—	—	0,24	0,99	1,00	
A.C. 250 V, 3,5 A.	high	2	0,111	0,281	0,63	1,09	1,00	2,56
D.C. 230 V, 3,5 A.	high	2	0.094	0,348	0,83	1,04	1,00	2,48
A.C. 150 W.	low	5	0,123	0,313	0,79	1,10	1,00	2,35
85 W.	30 atm.	6	—	—	—	—	1,00	3,69
125 W.	8 atm.	6	—	—	—	—	1,00	4,38
250 W.	0,4 atm.	6	—	—	—	—	1,00	4,41
80 W. " black lamp "	high	7	—	—	—	0.09	1,00	—

*Makers ;
(1) G.E.C., England.
(2) Thermal Syndicate, Ltd., England.
(3) G.E. of America.
(4) Hanovia, Ltd., England.
(5) cf. Rev. *Sci. Inst.*, 1938 ; 9 ; 325.
(6) Standard American make.
(7) Philips Lamps, Ltd.

TABLE 17

Ultra-Violet Sensitive Photo-electric Cells.

Type	Cathode	spectral range A.U.	max. sensitivity A.U.	μA/Lm	Code	Maker*
G	Cd	2,500-2,950	2,600	<0,1	UDG7	1
G	Na	2,750-5,500	3,330	*	UNG7	1
G	CsO	3,000-12,000	3,650-7,500	100,	CMG8	1
V	K on Ag_2O	2,500-7,000	3,500	2,	KMV6	1
V		2,000-5,000	2,900	12,	FJ76	2
V	Cs-Mg	2,750-7,000	3,300	0,75	WL770	3
V	U	2,800-3,200	2,975			3

* For sodium cells Harris [14] gives a sensitivity of 40.10^{-6} μA/μW.
Makers
(1) G.E.C. (England) ; (2) G.E. (America) ; (3) Westinghouse Lamp Co. (U.S.A.).

If no direct observation of the u-v energy flux is required by any particular method or task then agreement between the maximum emission of the radiator and the maximum susceptibility of the luminophore is necessary as well as the agreement between the peak output of the luminescent energy and the maximum sensitivity of the photoelectric cell. For instance:

Optimal Combinations between Photo-cells and Fluorescent Screen.

TABLE 19

Material of Fluorescent Screen	Max	Photo-electric Cell
Zinc silicate ...	5,630 A.U.	Westinghouse GREEN 5,650 A.U.
Calcium tungstate ..	4,400 A.U.	R.C.A. 926 (rubidium), and
Anthracene ...	4,358 A.U.	G.E.C. KG7 (potassium) 4,400 A.U.
Cadmium borate ...	6,150 A.U.	B.T.H. PV921 5,500 A.U.
(excitation at 2,537 A.U.)		(80% at 6,150 A.U.)

Excitation at 2,537 A.U. — Luminescent material Zn_2SiO_4 — peak output at 5,630 A.U. — Photoelectric Cell type PA GREEN, peak at 5,650 A.U.

agreement agreement

Other photocells in this range are: Electrocell (5,750 A.U.); Weston Photronic (5,800 A.U.).

Fluorescence Analysis

The fluorescence analysis* is one of the most sensitive chemical methods. Although lack of space forbids to enter even a short description of the methods and advantages of the fluorescence analysis, a few data will readily prove the above statement.

Detection of Mercury Vapour

The phenomenon of mercury vapour being impervious to ultra-violet rays is utilised in the detection of traces of mercury vapour. This is the most sensitive method known at present. A zinc silicate screen or an anthracene screen** will detect mercury in an ore in the ratio of $1 : 10^{-5}$. An ore, suspected to be mercuriferous, is powdered and heated strongly. The suspected vapours are allowed to pass between an ultra-violet source (2,537 A.U.) and the screen. Vapours other than of mercury cast no or only a very hazy shadow on the screen; mercury vapour, even in as low a concentration as 10^{-6}, casts a very dense shadow on the screen. The same dense shadow appears if a sample of air from a room, in which mercury has been allowed to volatilise at ordinary pressure and temperature, is drawn between the lamp and the screen. The same method can conveniently be adapted to act as a safety valve in vacuum plants. High vacuum installations,[15, 17] for instance, those for neon tube pumping, are very sensitive to contamination by mercury. It is easy to arrange for an ultra-violet sensitive photoelectric relay to be mounted behind the glass tube, an appropriate part of which is masked by the diaphragm (Fig. 7). The aperture in this diaphragm has an area which is equal to the projected area of the cathode of the photoelectric cell in the relay, one dimension of this area (square, rectangle, circle) being equal to the diameter of the glass tube. The radiation (2,537 A.U.) of a mercury lamp is allowed to pass through the diaphragm, traverse the gas stream in the tube, and to fall on to the photocell. A minute trace of mercury vapour will obscure the ultra-violet beam, thus causing the photo-relay to act, namely to close a valve before the mercury vapour can reach that valve. If it is difficult to obtain ultra-violet sensitive cells recourse may be had to the transformation by a fluorescent screen (*see above*) of the 2,537 A.U. radiation into luminous radiation. In such cases, coincidence between the maximum spectral sensitivity of the photocell and the peak emission of the fluorescent material must be approximated as closely as possible. There must be no additional phosphorescent effect (afterglow) and the fluorescence afterglow of the screen must be negligible as compared to the action time of the photo-relay. The mechanical basis of the fluorescent screen can be any transparent material which is not affected by the u-v radiation (2,537 A.U.). It need not be transparent to ultra-violet radiation if the uncoated surface of the fluorescent screen is next to the photocell and the coated surface being turned towards the radiant source.

In many other cases the fluorescent screen can be replaced by a fluorescent filter, *e.g.*, by Uranium Crown glass (Chance Bros., Smethwick) or Canary glass, exhibiting a strong greenish-yellowish fluorescence, or by Clear Blue Fluorescing 014 (Corning Glass Works), which is a colourless transparent glass exhibiting a strong blue fluorescence. Both should be excited by radiations shorter than 3,100 A.U. (preferably 2,537 A.U.), although the 3,650 band also gives the characteristic, yet weak, fluorescence. When these fluorescent filters are used they should be sandwiched between the photocell and another filter that excludes luminous light from the photocell. Such filters are of the Red Purple Corex A No. 986 (Corning), or UG5 (Jena) type, etc., and are defined by a high transmission in the far ultra-violet ($< 3{,}100$ A.U.).

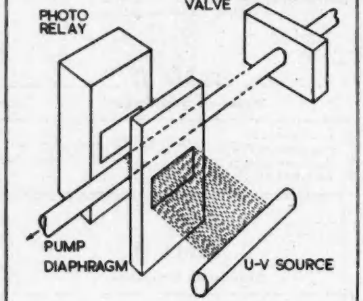


Fig. 7.
Apparatus for detection of mercury vapour.

Detection of Flaws, Cracks, etc.

The many methods of crack detection in materials industrially used have been greatly enriched by the use of fluorescent substances. The technique is simple and is well suited for mass inspection. According to the shape of the test object some methods show definite advantages over others. Small plain objects are tested by the "duochromatic" method, developed by the writer. A 1 per cent. solution of 3 : 6-dihydroxyphthalimide in petroleum ether* is colourless in daylight

* There is an enormous literature on this subject Cf. Radley and Grant, Fluorescence Analysis in U-V Light; 1939; (more than 2,000 references); N. R. Dhar, The Chemical Action of Light; 1931; (about 2,500 references).

** Pure anthracene has a blue fluorescence (4,047, and 4358, A.U.). Commercial anthracene exhibits a green fluorescence due to the presence of naphthacene in the molecular lattice. ("Pure" chemicals are of A.R. quality).

* Dissolve 1 gm. of 3:6 dihydroxyphthalimide in 127 c.c. alcohol abs. and dilute with petroleum ether puriss.

or incandescent light, but shows a strong blue colour when irradiated with long-wave ultra-violet (3,650 A.U.). A drop of liquid is applied to the test object where it spreads out evenly, or the object can be dipped into the fluorescent indicator. The volatile liquid vaporises within one or two seconds, but is retained longer in crevices, cracks, flaws, etc. The time needed for vaporising the petroleum ether can easily be controlled by using petroleum ether of a suitable boiling range.** When viewed in ultra-violet light after the liquid has volatilised the dry surface will appear in a yellowish colour, the cracks standing out in bright blue against this background, a phenomenon which is due to the capillary action of the fissures. After a very short time, rating from two to three seconds for the low boiling petroleum ethers and up to one to two minutes for the high boiling ethers, the liquid will have totally disappeared. No residues, harmful to metal or textile fibres, plastics, etc., are left on the surface of the object. The inspection need not be carried out in complete darkness or in a room specially set aside and adapted for this purpose. The inspection can, on the contrary, take place in broad daylight if a screened ultra-violet inspection unit is used. Other methods use anthracene dissolved in petroleum jelly. The surface is covered with the jelly which, by itself, has a violet-blue to sky-blue fluorescence depending on the degree of purity, and then wiped clean. The jelly will be retained by any flaws and will reveal its presence by the strong fluorescence. This method is often employed in grinding, polishing, and honeing workshops in order to inspect for cracks in crankshafts and other vital gear which might have been cut open during the polishing process. Larger flat surfaces of metallic or other smooth-surfaced bodies can be inspected by the "brushing method." An inorganic fluorescent powder is brushed over the surface to be inspected and this is then wiped clean. One or more grains of the finely ground powder[19] will remain in the crevices and give away their position by exhibiting a bright coloured light when viewed under the u-v lamp.

Mining

Certain minerals exhibit a vivid fluorescence the colour of which is characteristic for the mineral and its source. The ultra-violet lamp is now a tool of the prospector and miner just as his pickaxe and shovel are, only that it is infinitely more delicate. A mineral, mixed with waste or gangue material which either does not fluoresce at all or has a fluorescence other than that of the mineral will stand out clearly in u-v light and an appropriate, yet very simple apparatus can be designed to automatically pick out and separate the ore from the dead stone.[20] No data other than the general rule can be given because the minerals vary their fluorescence colour and intensity not only with the intensity and wavelength of the exciting ray (long or short ultra-violet or X-rays), but also with their origin and mineralogical structure so much that the experienced miner can often tell the origin of a mineral, judging from its fluorescence colour only.

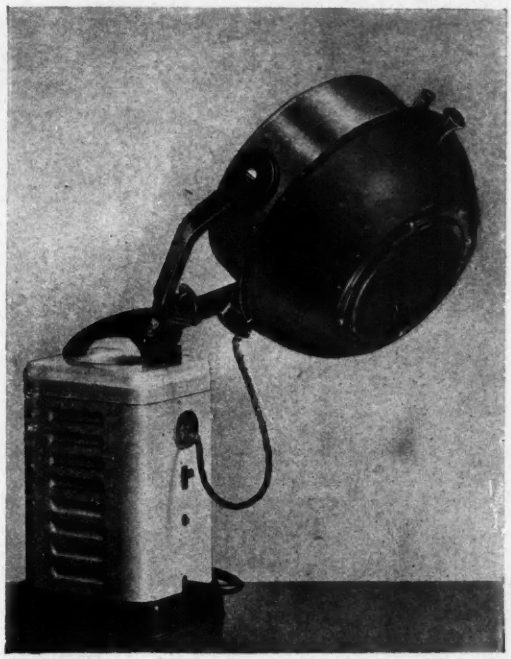


Fig. 8.

Fluorescence Lamp for u-v Analysis.

By courtesy of Hanovia, Ltd.

Irradiation

The high pressure high intensity mercury arc is a very efficient source of bactericidal radiation. This is used, for instance, in the brewing industry for sterilising water, in the dairy industry producing a high vitamin D content. This discharge tube usually consumes 700 to 1,200 watts. The model shown in Fig. 9 delivers sterilised water at an hourly rate of up to about 2,800 litres, *i.e.*, about 600 gallons.

Anti-Stokes Effect

The phenomenon of working with an apparent efficiency greater than unity has been shown to exist (luminescence of anilin). This one case of Anti-Stokes behaviour has not been followed by similar discoveries. It is, therefore, up to the present moment impossible for infra-red energy to excite an Anti-Stokes radiation and still less to produce it in the luminous range; or, in other words, the conditions, favourable to the emitted quantum being of higher energy than the incident quantum, have not yet been discovered, supposed the case of the anilin will be found correct. If such an effect is desired, the Zworykin-Morton Electron-Image Tube must be resorted to. This tube consists of a photosensitive cathode and a fluorescent screen. A means[21] is provided which focuses the electron image from the cathode on to the screen. The cathode may be sensitive to a number of spectral groups, *viz.*, the ultra-violet, luminous, and infra-red range. The Electron-Image Tube is capable of transforming infra-red images into luminous images.

** Ranges available: below 40° C.; 40°—60° C; 50°—60° C.; 60°—80° C.; 80°—100° C.; 100°—120° C.; above 120° C.

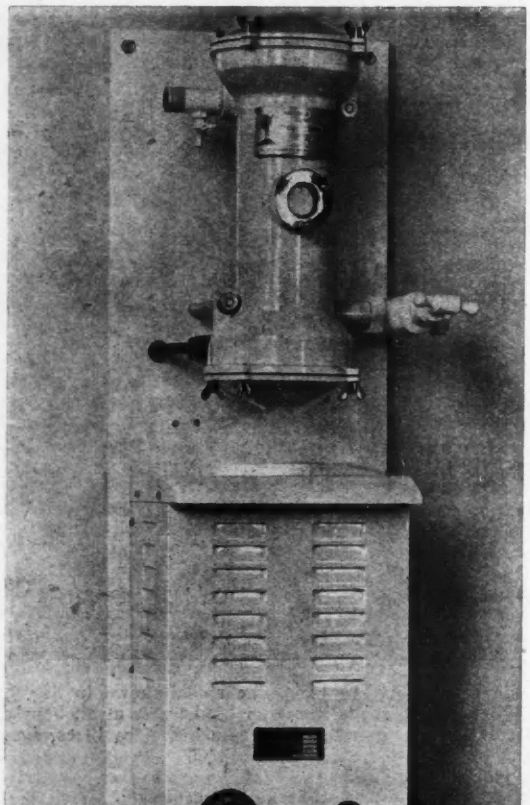


Fig. 9.

Water Steriliser "Uster" type.

By courtesy of Hanovia, Ltd.

Phosphoro-Extinction

It is known since the beginning of the last century that the phosphorescence, excited by radiations from the ultra-violet range of the spectrum, in some cases is readily extinguished by the incidence of infra-red rays.[22] In practice, this general statement will be restricted to a few cases of optimal conditions. When using a zinc sulphide with an excitation peak at 3,650 A.U. or longer and a phosphorescence maximum at 5,120 A.U., the infra-red radiation of between 9,000 and 14,000 A.U. will effect the most marked extinction. Calcium sulphides have a higher infra-red limit, about 17,500 A.U. The action of the infra-red depends on its wavelength, but is independent of the time of exposure to and the intensity of the infra-red radiation, in other words, the phosphoro-extinction is governed by the Bunsen-Roscoe reciprocity law (time times intensity is a constant).[23] In a German patent[24] a very effective phosphor is described as having a strong long lasting afterglow which is very susceptible to infra-red radiation. It is a zinc-cadmium sulphide phosphor with a *CdS* content up to 15 per cent, using copper as an activator.* Maximum excitation at 3,500 A.U. to 5,300 A.U., maximum emission at 5,550 A.U. (this is the wavelength of maximum eye sensitivity), extinction wavelengths between 5,300 A.U. and 15,000 A.U. In the B.P. 391374 and in the F.P. 742894 (ex 1932), it is proposed to use the phosphoro-extinction method when determining the distribution of temperature at the surface of a hot body. An image of the hot surface is projected on to a previously excited phosphorescent screen where the phosphorescence will be extinguished *pro rata* of the incident heat energy. This image can be photographed when permanent records are desired.**

* An excellent phosphor (max. emission 5,650 A.U.) for infra-red extinction is marketed by Messrs. Thomas Tyrer, Ltd., London.

Fluoroscopy

The method of X-raying an object and viewing its silhouetted image on a fluorescent screen is called fluoroscopy. The luminescent image, formed by the X-rays, can be viewed either by an observer or by photocells. The fluoroscopic method of inspection has advantageously been applied to spotting a foreign body in packaged goods, like food, tobacco, or candy; spotting air bubbles in cast metal ingots, etc.; determining the filling level in tins, canisters; internal flaw detection especially in light alloy castings; etc. An instance of this type of inspection is the X-raying of a filled hand grenade in order to locate any irregularities that may exist.[25] The alignment of elements, enclosed in an outer casing, can be checked as, for instance, in metallised or metal electron valves. The screen for fluoroscopic observation is usually of the zinc sulphide type which has been treated in such a way as to reduce phosphorescence.

** Another method employs heat sensitive paints which change their colour at certain temperatures.

Bibliography

[1] G. G. Stokes, *Phil. Trans.*, 1852; 142; 463.
[2] A. Verneuil, *Comp. Rend.*, 1886; 103; 500.
P. Lenard and V. Klatt, *Ann. der Phys.*, 1904 105; 286.
P. Lenard, Phosphoreszenz und Fluoreszenz, Akad. Verlagsges. 1938.
[3] after P. Pringsheim and M. Vogel, Luminescence, 1943.
[4] J. A. De Ment, Fluorescent Chemicals and Their Application, 1942.
[5] P. Pringsheim and M. Vogel, Luminescence, 1943 172, 188.
[6] G. L. Clark, Applied X-Rays, 1940; 71.
[7] Ch. L. Amick, Fluorescent Lighting Manual, 1942.
[8] H. W. Leverenz, *Proc. I.R.E.*, 1944, May; 256.
[9] R. N. Thayer and B. T. Barnes, *Jour. Opt. Soc. Am.*, 1939; 29; 131
[10] *J.O.S.A.*, 1939; 29; 124.
[11] *Phil. Tech. Rev.*, Jan. 1938.
[12] *Jour. Opt. Soc. Am.*, 1940; 30; 51.
[13] S. Dushman, *Jour. Opt. Soc.*, 1937; 27; 1.
[14] D. T. Harris, The Technique of Ultra-Violet Radiology, 1932.
[15] V. K. Zworykin and E. D. Wilson, Photocells and Their Applications, 1932.
[16] R. W. Wood, Physical Optics, 1910; 590.
[17] *Rev. Sci. Inst*, 1939; 308.
[18] Francesconi and Bargellini, *Accad. Lincei, Atti* 1906; 15; 184.
[19] M. S. Oldham and W. Kunerth, *J.O.S.A.*, 1941 31; 102.
[20] M. Déribéré, Les Applications Pratiques de la Luminescence;
[21] G. A. Morton, *Jour. Soc. Mot. Pic. Eng.*, 1936, 27, p. 321, also F. Coeterier and M. C. Teves, *Physica* 1936, 3, p. 968.
[22] R. P. Johnson, *J.O.S.A.*, 1939; 29; 387. Also: E. L. Nichols and E. Merritt, Studies in Luminescence, 1912, (Carnegie Inst.).
[23] V. L. Lewschin, V. V. Antonow-Romanovsky, and L. A. Tumerman; De la Photographie dans la Partie Infrarouge du spectre suivant la Methode d'Extinction d'Ecrans Phosphorescents; *Compt. Rend. Acad. Aci.* U.S.S.R., 1933, pp. 276-279; also
V. L. Lewschin, V. V. Antonow-Romanovsky, and L. A. Tumerman; Beobachtung der Ausloeschung der Phosphoreszenz durch Ultrarote Strahlen; *Phys. Zischr. d. Sowjet Union*; 1934; 5; 811.
[24] D.R.P., 629800 (ex. 1936).
[25] Jour. Franklin Inst., 1944; 237 (3); 202.
[26] N. Prilezhaeva, *Acta Physiochim*, U.S.S.R., 1934, I, 785, (in German).

Aids to Stroboscopic Measurement

By E. LLOYD THOMAS, B.Sc., A.C.G.I.*

Describing a number of devices intended to improve the accuracy and reliability of speed measurements with electronic stroboscopes.

WHEN a stroboscope of conventional design is used for speed measurement, the accuracy of the readings obtained is limited by two factors. The first of these is the instrumental error of the stroboscope itself. The second arises from the liability of the operator to confuse the correct setting of the speed control with one corresponding to a sub-multiple of the true speed. It is this possibility of ambiguity, resulting in errors many times greater than the instrumental error, which often leads to stroboscopic measurements being regarded with a certain amount of suspicion.

In order to ensure accurate readings, then, means must be devised for reducing the first of these two errors and eliminating, if possible, the second. Although many commercial electronic stroboscopes incorporate arrangements for minimising instrumental errors due to drift of calibration, none, as far as the writer is aware, provides any discrimination against sub-multiple readings. It may be of interest, therefore, to show how both the instrumental and observational errors can be overcome, by describing a number of devices recently evolved in connexion with the "Photopulse" stroboscope, an account of which has already† been given in this journal.

Reducing the Instrumental Error

Many existing electronic stroboscopes rely on having a time-controlled A.C. power supply for checking their calibration. The usual arrangement consists of a reed which is made to vibrate at twice the supply frequency by an electromagnet. This reed is then observed stroboscopically and, with the instrument set to certain speeds, trimmers are adjusted until it appears stationary. Alternatively, a magic eye is sometimes used to effect the comparison.

Unfortunately, both methods become impracticable at flash frequencies above about four times the supply frequency and, besides, the accuracy of the instrument is limited when used on uncontrolled A.C. or on D.C. power supplies. However, these disadvantages can be overcome by the simple expedient of feeding the electromagnet not with a sinusoidal voltage of mains frequency, but with pulses derived from the frequency determining circuit of the stroboscope itself. The reed will then be shock excited into vibration only when the flash frequency of the stroboscope coincides with either its natural frequency or some sub-multiple of it. By tuning the reed so that its natural frequency lies at, or beyond, the upper limit of the range of the instrument, there will be a number of points, spread over the scale, at which the calibration can be checked; in much the same way as a crystal calibrator is used with a radio receiver.

When using a tuned-reed calibrator of this kind it is only necessary to set the pointer of the instrument to the nearest calibrating mark and adjust the usual frequency trimmer until the vibration of the reed is a maximum. Subsequently, even greater accuracy can be obtained by completing the adjustment while observing the reed stroboscopically, instead of with continuous illumination. Under these conditions the reed will always seem to be stationary, but it will be displaced to one side or other of its mean position according to whether the flash frequency is higher or lower than its resonant frequency. At the correct setting of the trimmer, however, the reed will appear to be at rest in its undeflected position. This is shown diagrammatically in Fig. 1.

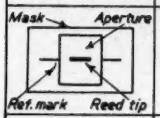
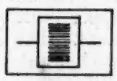
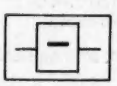
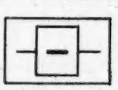
APPEARANCE OF REED	TYPE OF ILLUMINATION	STROBOSCOPE ADJUSTMENT
	CONTINUOUS	Pointer remote from calibrating mark. (Reed stationary)
	CONTINUOUS	Pointer close to calibrating mark (Reed vibrating)
	STROBOSCOPIC	Pointer coincident with calibrating mark Frequency needs slight correction (Reed vibrating)
	STROBOSCOPIC	Pointer coincident with calibrating mark Frequency correct (Reed vibrating)

Fig. 1. Appearance of calibrator reed under various conditions of illumination and stroboscope adjustment.

By suitable design the natural frequency of the reed may be held between very close limits, and in practice it is comparatively easy to obtain an accuracy of better than ± 1 per cent. The limit to the satisfactory operation of this system is set by the electrical power available to maintain adequate vibration of the reed. The power required increases with frequency, but experiments indicate that even 1 watt is sufficient to drive a reed having a natural frequency of 1 kc/s. This corresponds to a speed of 60,000 R.P.M., which is high enough for most purposes.

Fig. 2 shows a calibrator designed

* The Sperry Gyroscope Co., Ltd.

† March, 1945. P. 409.

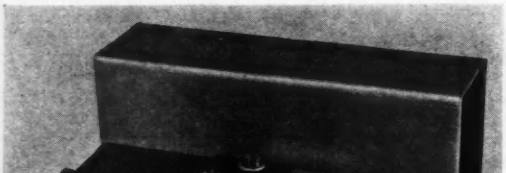


Fig. 2 (left). Tuned-reed calibrator, with two reeds, designed to cover the range from 15 c/s to 400 c/s.

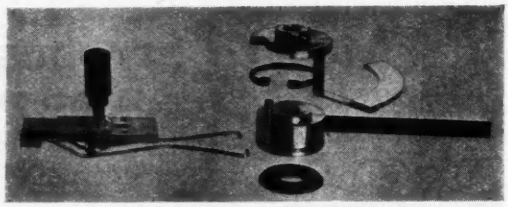


Fig. 4 (right). Exploded view of mechanical speed checking device.

for mounting adjacent to the scale of a stroboscope. It has two reeds, one for each range of the instrument, tuned approximately to 400 c/s. and 80 c/s. respectively. The tips of the reeds are painted with distinguishing colours, and the calibrating points, five in each range, are related to the appropriate reed by being marked on the scale in the same colour.

Eliminating the Observational Error

Now consider what can be done to ensure that the operator makes the most of the improved instrumental accuracy provided by the calibrator.

When a stroboscope is used for measuring the speed of, for example, a rotating shaft, the correct reading is of course the highest which gives a single stationary image of a mark on the shaft. However, since there is a whole series of settings, corresponding to integral sub-multiples of the true speed, which give visually identical images, an operator must adopt some logical checking routine in order to select the correct one.

The safest method is to find the most likely setting and then turn the speed control slowly until the pointer reads twice the original speed. If the original reading did in fact correspond to the true speed, then no other setting will be found during this sweep which gives a single image. Moreover, when the reading has been doubled a double image will be observed, *i.e.*, in the present case two diametrically opposite marks will be seen on the shaft. If another single image is encountered, however, it means that the original setting corresponded not to the true speed, but to a sub-multiple of it.

This procedure is inconvenient and cumbersome, particularly to a semi-skilled operator, and may not always be possible when working near the upper limit of the range of the instrument. The solution is to provide a mechanical or electrical device which will carry out the checking routine described as nearly automatically as possible.

A Mechanical Speed Checking Device

Such a device need not be very elaborate. In fact, if the stroboscope can be designed so that its scale calibration is logarithmic, *i.e.*, equal increments correspond to equal ratios of speed, then a simple clutch mechanism between the speed control knob and its pointer will serve the purpose.

One form of this clutch is shown in Figs. 3 and 4. From these it will be seen that the pointer is normally coupled to the frequency determining element, in this case a variable resistance, and moves over the scale in the usual way as the control knob is turned. If the lever is depressed, however, the pointer becomes locked in position but the knob remains free to turn over a range which is limited mechanically to that lying between the original setting and one corresponding to, or slightly greater than, twice this setting (in frequency). The pointer is spring loaded, so that when the lever is returned to normal the

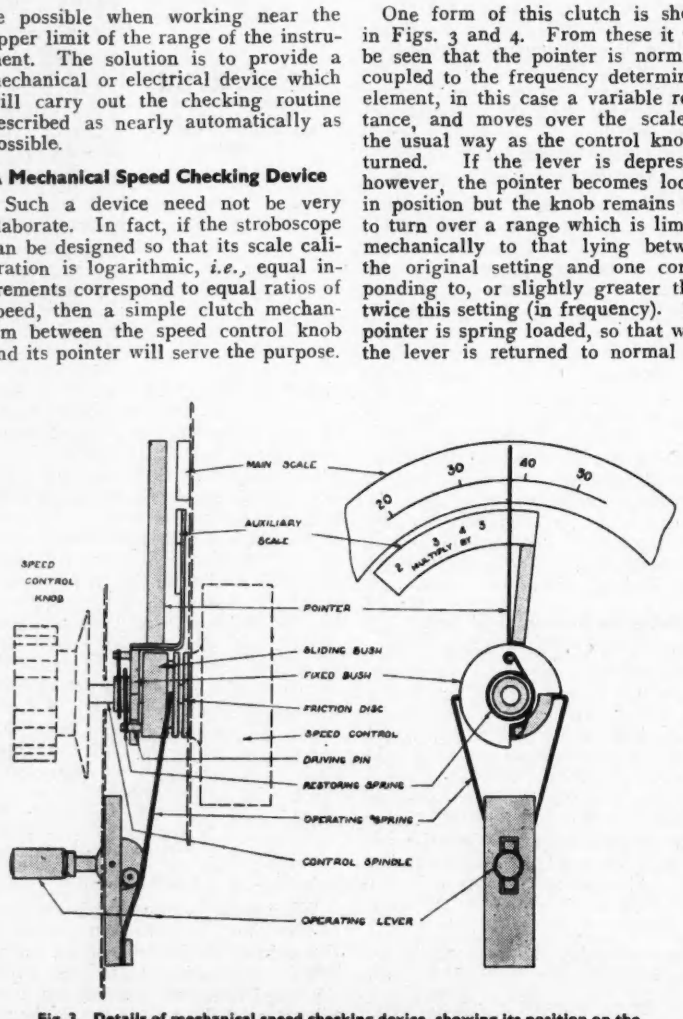


Fig. 3. Details of mechanical speed checking device, showing its position on the spindle of the stroboscope speed control.

indication again agrees with the setting of the control.

In order to use an instrument fitted with this device, the operator adjusts the speed control in the usual way until a single stationary image is obtained. He then presses the lever and turns the control slowly clockwise until it will go no further. If no other single stationary image is encountered during this sweep, then the reading of the locked pointer gives the true speed and, as an additional check, a double image will be found at the extreme limit of the sweep. If, on the other hand, another single image can be found, it indicates that the reading of the pointer is not the true speed but a sub-multiple of it.

Since the positions in the sweep range where additional single images can be encountered depend only on the particular sub-multiple at which the pointer happens to be set, it is possible to indicate to the operator the factor by which the pointer reading is in error. This is the purpose of the small auxiliary scale shown in the illustrations. This scale is rigidly attached to the control spindle and so moves relative to the pointer when the latter is locked. If, when making a check sweep, other single images can be found, the first will be met with as one of the marks on the auxiliary scale passes under the pointer. The figure adjacent to this mark is the factor by which the pointer reading must be multiplied in order to obtain the true speed.

An Electrical Speed Checking System

When it is fairly certain that there is no chance of arriving at a setting corresponding to a sub-multiple lower than one-half the true speed, the usual manual checking procedure may be somewhat simplified. When the operator finds what he takes to be the correct setting, he notes the reading and then doubles it. If the original setting was, in fact, the correct one, *i.e.*, the lamp was flashing once for each revolution of the shaft, it will now flash twice during each revolution, and a double stationary image will appear. But, if the image does not double, then the original reading was an even sub-multiple of the true speed.

This leads to a very simple method of speed checking which is particularly suitable for electronic stroboscopes. The device consists of a lever switch connected in the electrical circuit of the instrument in such a manner that when it is operated the flashing rate of the lamp is automatically doubled, whatever may be its original value. In Fig. 5 the flashing rate of the lamp is governed by the frequency of the electrical pulses generated by the oscillator, which in turn is determined by the time constant of the grid circuit of the valve. The desired effect is secured by splitting the grid capacitor into two equal components, one of which is open-circuited when the lever is depressed. An alternative method is to make the variable resistance of two identical ganged components, and to short-circuit one of them.

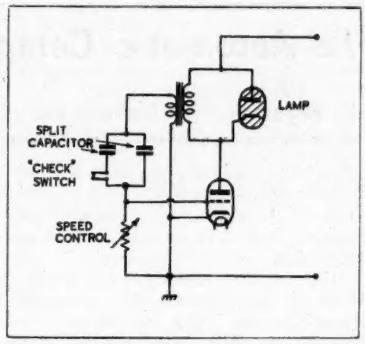


Fig. 5. Electrical speed checking principle applied to a simple stroboscope circuit consisting of a blocking oscillator coupled to a glow lamp.

With this system it is only necessary for the operator to start with the stroboscope reading higher than the anticipated speed of the object under observation, and then to reduce the reading until a single stationary image is obtained. This should be the correct setting; when, if the "check" lever is pressed, the image pattern will remain stationary, but will appear to be doubled. Alternatively, if the setting arrived at is actually only half the true speed, the pattern will not alter when the lever is operated. It should be noted, however, that this simple method fails if the setting happens to correspond to an odd sub-multiple of the true speed.

Conclusion

During the course of development several other methods of calibrating and speed checking were investigated, but only those mentioned appear to have any great practical value. Of the two methods of speed checking, the mechanical system, although less elegant than the electrical, is also less ambiguous in its indication and more informative. It can, of course, be applied to mechanical, as well as electronic, stroboscopes.

All the devices described are comparatively simple and cheap, and, in many cases, could be fitted to existing instruments. Extended practical tests have shown that the versatility of an electronic stroboscope is, in fact, considerably enhanced by the addition of a tuned reed calibrator and one or other of the speed checking devices. With these aids speed measurements take less time; and, what is even more important, are reliable.

In conclusion, the writer wishes to thank the Sperry Gyroscope Company for permission to publish this article, which is based on work carried out in the laboratories of the Company.

Double Type Numbers for American Valves

Some uncertainty appears to exist regarding the meaning of the double barrelled type numbers, such as type 1B5/25S. The meaning is very simple and should be understood by all those handling valves.

The stroke in the middle of the type number means "superseding and replacing," so that type 1B5/25S means, "Type 1B5, superseding and replacing the earlier type 25S, which is no longer being manufactured."

Similarly, type 6U5/6G5 indicates that it is type 6U5 superseding and replacing the earlier type 6G5, which is no longer being manufactured.

Another example is type 866A/866, which indicates a new construction of type 866A, superseding and replacing type 866. In this particular case, the new model differs from the earlier type 866A, which was not capable of being used to replace type 866 under all circumstances.

At a later date, the second half of the double barrelled type number will be dropped, leaving the first half only This has already been done in the case of 6V6GT, which supersedes and replaces the earlier type 6V6G which is no longer being manufactured, although certain stocks of type 6V6G may still be held, and it may be some months before the GT valve completely supersedes the earlier G type.

—*From "Radiotronics Digest"* (Austr.).

A. C. E. *The Automatic Computing Machine*

A Report issued by the Department of Scientific and Industrial Research

THIS note gives the history of calculating machines and details of the work now in progress at the National Physical Laboratory, towards producing an Automatic Computing Engine (A.C.E.). It is intended that the A.C.E. shall tackle whole problems instead of being limited to carrying out a sequence of prescribed operations. The machine will be far in advance of any calculating machines yet constructed.

History

Hand-operated calculating machines, capable of addition, substraction, multiplication and division were made successfully in the late 19th century. Parallel developments between the two world wars were in purely adding machines and the large punched-card accounting machines. The latter were developed originally for the American Census, at the end of the last century, but their use increased in large business organisations and Government Departments between the two wars, and great strides were made in the use of all these types of machines in scientific work. Dr. L. J. Comrie, formerly Superintendent of the Nautical Almanac Office, is an outstanding pioneer in this field.

He adapted a bank ledger-posting machine of American manufacture for the construction and checking of mathematical tables, and used the punched-card accounting machines for constructing tables of the motion of the moon up to the year 2,000 A.D. In this way, the speed and power of the computing aids for the scientific worker have been greatly increased, without any duplication of the technical development already undertaken in the commercial field.

During the war, however, it became apparent that the needs of scientific research were outstripping the mechanisms provided by purely commercial development. At Harvard University a machine was constructed which, although its components were such as might be found in a commercial accounting machine was put together in a novel way, and with very different ends in view.

Modern Machines

Thus came about the construction of the Automatic Sequence Controlled Calculator, made by the International Business Machines Corporation, and presented to Harvard University. It consists of 72 adding mechanisms, a mechanism for multiplication and division, three tape feeds carrying tables of mathematical functions and a punched card input and output.

These various mechanisms are interconnected through what is virtually an automatic telephone exchange and the "instructions" to the machine are coded in the form of perforations on a punched tape—the "sequence control" type, which controls the working of the machine. The setting-up of a problem on the machine consists in planning the sequence of arithmetical operations to be performed, converting these operations into the code used on the tape and punching it on a special typewriter.

The speed of this machine is not spectacular, multiplication takes a second or two, addition a fraction of a second. Division may take as much as a quarter of a minute, according to the number of figures involved. The new step in development in this machine was the idea that it should tackle a problem *as a whole*, working automatically to a prescribed sequence of instructions. In all previous machines the link between one arithmetical operation (addition, multiplication, etc.) and the next had always (except in a simple set of additions) lain through the brain of the operator at each stage. In this Harvard machine the links between successive operations are electrical, through the built-in telephone exchange. Instead of having to make these connections during the progress of the work, the human operators plans a long sequence of them in advance, and leaves the machine to carry them out automatically.

Although this Harvard machine is an independent and original development, the possibility of the construction of such machines, and, indeed more elaborate ones, had already been foreseen in this country. Dr. A. M. Turing, a fellow of King's College, Cambridge, had written in 1936 a severely mathematical paper in which he had discussed the properties of such machines in connection with certain problems of mathematical logic, without considering practical methods of construction.

Now a telephone relay is a device for switching a current on or off. A valve can be used in the same way, but at much higher speeds. Sooner or later, therefore, someone was bound to attempt to make a machine which would use valves in place of relays, and attain hitherto unheard-of speeds of calculation. This has been done. At the Moore School of Electrical Engineering, University of Pennsylvania, there has been constructed an electronic monster which will add two numbers together in less than a thousandth of a second, and multiply them in a few thousandths of a second. This machine, christened the ENIAC (Electronic Numerical Integrator and Computer) contains 17,000 valves and consumes 150 kW.

The A.C.E.

The National Physical Laboratory of the Department of Scientific and Industrial Research has, through its Mathematics Division, maintained an interest in these developments. It has planned a machine called the A.C.E. (Automatic Computing Engine), which will work at the speed of the ENIAC, or possibly somewhat higher, and which will take advantage of new technical developments. making possible both a greater memory capacity and a higher degree of complexity in the instructions.

The logical control mechanism of this machine will be far more complicated than the calculating mechanisms. At these high speeds time cannot be spared to prepare a full set of detailed instructions for each problem. Instead, instruction programmes for standard calculations will be stored in a special library, and the instructions for a particular problem will be assembled from these prefabricated units, possibly linked together by special instructions. It is in the organisation of these instructions that the National Physical Laboratory feels that it has something new to contribute, and the major effort of the Mathematics Division has been in the preparation of these instruction programmes, for upon the form decided upon for these the technical design largely depends.

It will be two or three years before the completion of this machine can be hoped for, since its construction presents formidable problems both mathematical and technical.

To do its work the A.C.E. has to be provided with the equivalent of three things required by the normal human mathematician. Firstly, there is the paper on which the computer writes down his results as he goes on; secondly, there are the instructions as to what processes are to be applied, which normally the mathematician carries in his head; thirdly, there are function tables to which the mathematician makes reference when working out his problem. These problems all involve storage of information or mechanical memory, and the mechanical device designed for this can be called upon by the logical control to give up its stored information at the required moment. The internal memory capacity of the A.C.E. will be 75,000 decimal digits as compared with 200 decimal digits of the ENIAC.

One of the ways in which the greater memory capacity of the A.C.E. shows its usefulness is in the setting up of problems. Whereas in the ENIAC a problem must be set up by a laborious process of plugging and switching, the A.C.E. may be told what it is to do and will remember what it has been told. The process of "telling" consists of passing a pack of cards through the machine on which instructions have been punched. This may take about a couple of minutes, as compared with several hours in the case of the ENIAC.

The internal working of the machine will be entirely in the binary system, in which a number is represented by a series of 1's and 0's, the 1's being pulses and the 0's the spaces between them. The answers will be given in the decimal system. The following example show how digits in the decimal system are represented in the binary system:—

1 = 1		
2 = 10		
3 = 11		
4 = 100		
5 = 101	10 = 1,011	15 = 1,111
		16 = 10,000

and so on.

A thousand million has 30 digits compared with the ten digits in the decimal system.

The machine will work at very high speeds. For instance, it is intended that the multiplication of two ten figure numbers shall be carried out in two thousandths of a second. The machine will alter the whole question of what is a difficult and what is an easy problem. There is a class of mathematical problem, which owing to their extreme complexity and the enormous length of time required to solve them, are so difficult as to be almost impossible of solution by the pencil and paper mathematician. Such problems are well within the scope of the A.C.E. For instance, simultaneous equations with more than twelve unknowns are beyond the patience and time of most mathematicians, but the machine will be able to tackle equations with fifty or even a hundred unknowns. Problems for which the machine might be used are the construction of range tables, involving the calculation of trajectories by small arcs for various different muzzle velocities and quadrant elevations; the calculation of the radiation from the open end of a rectangular wave-guide; the finding of the potential distribution outside a charged conducting cube.

The machine will cost in the region of £100,000 to £125,000. It is unlikely that other similar machines will ever be made. So great is the speed with which it will work, that this one machine by itself will be able to cope with all the exceedingly abstruse problems for which it is designed. Furthermore, it is probable that during its construction, or shortly after its completion, further advances will become clear, and subsequent machines will be designed to do even more than the A.C.E.

The work is being done mainly in the Mathematics Division of the National Physical Laboratory. The leaders of the team are Sir Charles Darwin, F.R.S., Director of the N.L. and a theoretical physicist of international repute; Dr. A. M. Turing, in whose brain the idea of the A.C.E. developed, who is 34 years old, and who is now with the Mathematics Division; and Professor D. Hartree, of Cambridge University, who is the only man in this country who has worked the ENIAC machine in the U.S.A.

The U.S.A. has been ahead of this country in the design of calculating machines, although perhaps the British have been more resourceful in the use of the machines than the Americans. Mathematicians in this country have every reason to be grateful for the pioneering courage of the Americans in this field.

TELEVISION COMMENTARY

CONGRATULATIONS to the B.B.C. for speedy production of its three excellent films which were included in the evening programmes following the Lord Mayor's Show (November 9), the Remembrance Day Service at the Cenotaph (November 10) and the Royal procession to Parliament (November 12). These films, taken specially for television, were photographed from a single point and therefore gave a longer, more natural and more satisfactory picture to the home viewer than a news-reel.

By contrast cinema films need to be very carefully chosen. For example, a film that was too detailed and too dark for television was the feature film of Swedish wood-pulping (November 2), which was so television shy that it broke three times, and when at last persuaded to appear, was very unsuitable.

A course of study in crime is now provided on Tuesday evenings. So far the lessons seem to have been designed for beginners only, but the exercises in detection will doubtless increase in difficulty as the series proceeds. Based on the same theme, was one of the slickest of programmes, "Confidence Tricks" (November 4).

The best of another month of good plays was "The Unguarded Hour" (November 15 and 16), which was not a minute too long after an hour and three-quarters. New ground was struck when a sound programme, "Radio Forfeits" was televised on November 7. Was it a success? Certainly it had novelty and curiosity value in the same way as the nervous visit of the Brains Trust to the studio a few weeks ago. But if sound programmes are to be televised they need producing for television, which cannot tolerate scripts.

Variety, so rarely varied nowadays, has been brightened by the return of Sherkot, the philosophical goalkeeper. There are probably good reasons to explain the monotony of variety and if programme directors could take viewers into their confidence over programmes that would be as much appreciated as the technical talks we suggested last month.

Just a tribute, in conclusion, to one of the stars of the past few weeks, Captain Sir David Bone who introduced the "Queen Elizabeth" on October 15. Personality always wins.

JEAN BARTLETT

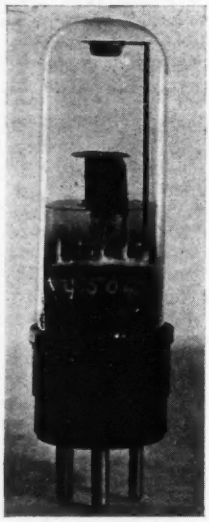
A Neon Stroboscopic Lamp—*The Ferranti Neostron Type NSP1*

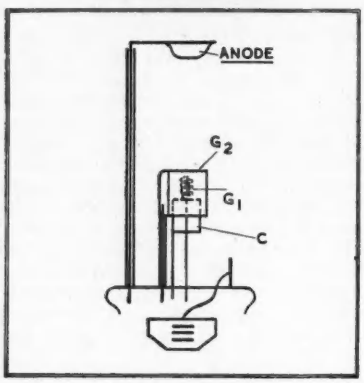
THIS lamp is designed to give short discharge flashes in Neon at frequencies ranging up to 250 c/s. The discharge current is very high (of the order of 100 amperes) and is arranged to last for a very small fraction of the discharge cycle (10-100 microseconds).

The tube is of tetrode construction as shown in Fig. 1. The cathode is of the "cold emission" type and therefore requires no heating current, G_1 is the control or synchronising grid and G_2 is the screen grid. The anode is a small metal plate situated at approximately 2.5 cm. from the upper edge of G_2.

The bulb is fitted with either the American UX4 base or with the English 4-pin standard valve base.

The lamp is operated with a resistance-capacity feed in the anode circuit, the values of R and C being chosen so that the time constant of this combination assists the lamp to discharge at the required frequency.





The Neostron Lamp

Self-excited Oscillator

In circuit A, the grid is tied to cathode and if the main H.T. supply to the resistance-capacity circuit is high enough the lamp will oscillate in a similar manner to any ordinary diode neon lamp. The NSP1 will, however, pass a much heavier current for a much shorter time and give a much brighter and more sharply defined light output than the diode neon lamp. The circuit is not suitable if accurate maintenance of frequency is required, but shows the principle upon which the lamp works.

Synchronised Oscillator

The lamp is more usually operated by injecting synchronising pulses to the G_1 grid as shown in circuit B.

The anode voltage is 350 v. max. and 220 v. min., these figures referring to the voltage on the anode at the instant immediately before the lamp flashes. Best results are obtained with voltages between 250 and 300.

The corresponding screen voltage will have to be determined by trial because the screen voltage depends on the value of the input synchronising signal. It will usually be found most convenient to operate with a smoothed D.C. supply of about 300 volts across the reservoir condenser and to provide a potentiometer shunt as shown in circuit B so that the screen grid (G_2) can be given any potential ranging approximately from 50 to 250 volts (as estimated before firing occurs). The grid signal input would be adjusted as required, but in this circuit the best operating voltage has been found to be 30 volts negative relative to the cathode.

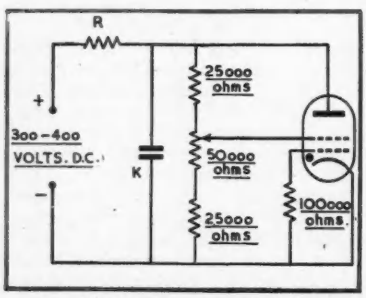
The lamps will often operate with grid input signals anywhere between − 10 and − 60 volts provided the screen and anode voltages are suitably adjusted. If a very sharp pulse is used as the input signal it is often advantageous to use even higher values of synchronising signal above 60 volts.

In order to limit the magnitude of the ignition current which passes between G_1 and G_2 the lamp is operated with 100,000 ohms in series with G_1. When this limiting resistance is in the G_1 lead the ignition current is about 500 microamperes, and it is this preliminary discharge between G_1 and G_2 which ignites the main discharge between anode and cathode. This main discharge is of the order of 100 amperes, but it disappears very rapidly because the condenser C loses its charge so quickly. If the discharge current is restricted in some way so that it is less than 4 amperes, it is possible that the glow discharge will not pass over into an arc discharge and the lamp will not function in a normal manner.

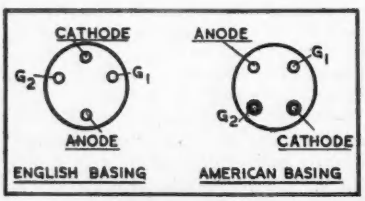
For operation at 44 c/s. the capacity C is 4 μFd. and R is 3,500 ohms. The values of C and R for other frequencies may be readily calculated from the time constant formula.

Dimensions

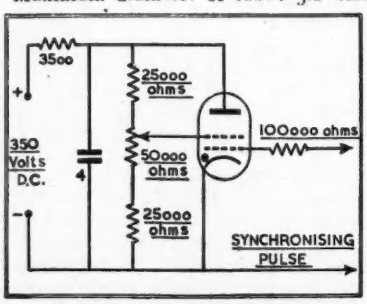
Overall length over pins of base: Max 12.5 cm. Min. 10.0 cm. Maximum diameter of tube: 3.2 cm.



Circuit A: Self-excited Oscillator



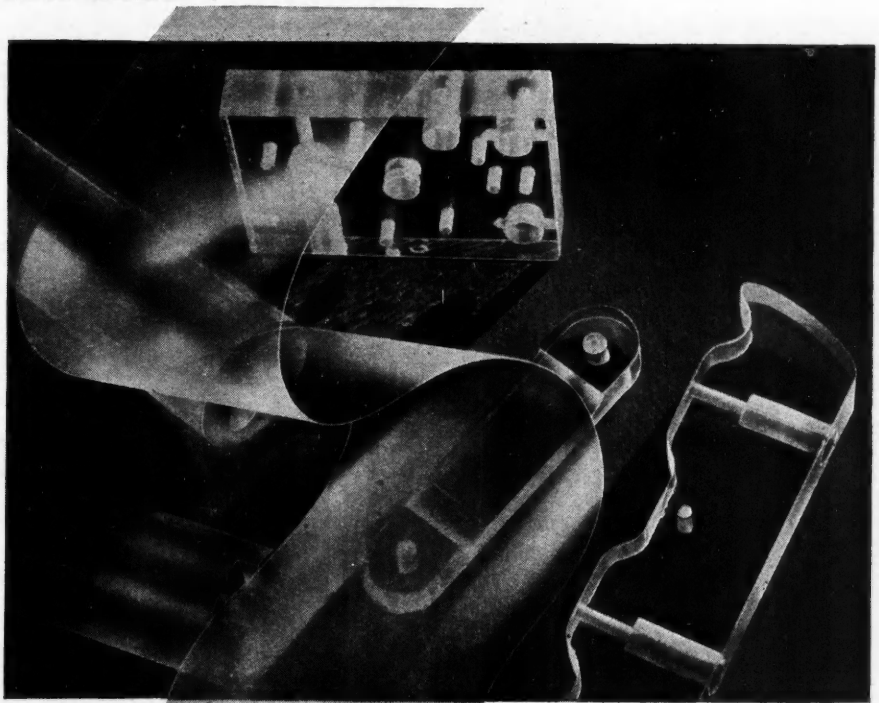
Basing connexions



Circuit B: Synchronised Oscillator

★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★

first RADAR



now DISTRENE foil

Radar, one of the most epoch-making inventions of this century, would not have been possible without the help of a material possessing a very low power factor, a high resistance to moisture and great dimensional stability.

DISTRENE Regd. (Polystyrene) was the material that completely met these needs.

Now, in the change over from war to peace, you have your problems of high-frequency radio and electrical insulation. DISTRENE FOIL can help you to surmount them.

In DISTRENE FOIL (Orientated Polystyrene Film) the molecules are specially arranged during manipulation so that the tensile strength is increased by 3 times and the flexibility by 10 times.

Power Factor
0·0002 - 0·0004

Tensile Strength
10,000 lbs./sq. in.

Thickness
0·001" to 0·008"

BX PLASTICS LTD LARKSWOOD WORKS · LONDON · E.4

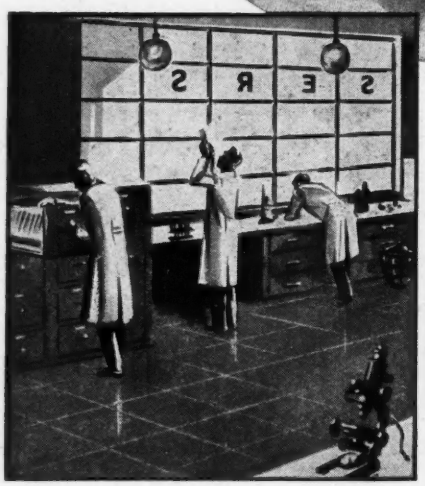
Telephone: Larkswood 4491

Branches: King Street Buildings, 1 Ridgefield, Manchester, 2. *Telephone: Manchester Blackfriars 0258*
42 Wellington Street, Sheffield. *Telephone: Sheffield 25517*

Works: London, Manningtree and Dundee.

TAYLOR 665

wise... £ foolish ?



Research Engineers and Chemists, Designers and Draughtsmen, picked for their superior knowledge and technical skill, are continually engaged in efforts to improve the design and efficiency of the finest Capacitors made.
Working methodically and with patient persistence, they are equipped with costly apparatus and backed by modern manufacturing methods.
All this costs money, but . .

It is an investment that manifests itself in T.C.C. Capacitors. Long-term economy and long-time trouble-free service are characteristic features of T.C.C. products. Inevitably they cost a little more, but in the long run they cost more than a little less, for once they are fixed T.C.C. Capacitors will last for years. Superior design and high-grade materials *must* produce better Capacitors. . . . It *must* pay you to buy the best !

TCC
CAPACITORS

THE TELEGRAPH CONDENSER CO. LTD.
RADIO DIVISION
NORTH ACTON · LONDON · W·3 *TELEPHONE:* ACORN 0061

Genera

Cons
lation
sin *pt.*
of time
modula
a funct
be amp
a funct
to be f
Both ty
althoug
usually

Cons
tricted
that th
will be
modula
stated.

Our
the for

It is u
sentatio
visualis
project
variabl
being
This c
whatev
never l
appear
in the
parison
but it
shown
tudes t
phase
tinuitie
of the

Inter
cribed
the ca
slowly
that th
" solid,
ing unr
equal
either s
ant wav
central
also ma
bottom
each dis
vided a
tude ne

To ca
assumpt
nature

Amplitude Modulated Waves

Part V of the series on Cathode Ray Tube Traces

By HILARY MOSS, Ph.D., A.M.I.E.E.

General

Consider a simple sinusoidal oscillation expressed by the form $y = A \sin pt$. If either A or p is a function of time then the wave is said to be modulated. More specifically, if A is a function of time, the wave is said to be amplitude modulated, while if p is a function of time, the wave is said to be frequency or phase modulated. Both types of modulation can co-exist although in practice this result is usually not desired.

Consideration is here mainly restricted to amplitude modulation, so that the term "modulated wave" will be taken to imply amplitude modulation unless otherwise expressly stated.

Our modulated wave therefore has the form

$$y = f(t)\sin pt \quad \ldots\ldots\ldots\ldots \quad (66)$$

It is useful to think of vector representation in these matters, so we may visualise our modulated wave as the projection of a rotating vector of variable length, the length variation being defined by the nature of $f(t)$. This conception also indicates that whatever the nature of $f(t)$ it can never be negative. This result may appear inconsistent with what follows in the section dealing with the comparison of modulated and beat waves, but it is not so in reality, since it is shown there that "negative" amplitudes to the vector are equivalent to phase reversals, and cause discontinuities in the slope of the envelope of the complete wave.

Interest in modulated waves as described by (66) is usually confined to the case where $f(t)$ changes only slowly in comparison with $\sin pt$, so that the complete envelope appears "solid," the variations in $\sin pt$ being unresolved. Again, $\sin pt$ makes equal and opposite excursions on either side of zero, so that the resultant wave (66) is symmetrical about the central zero line. Our vector picture also makes it clear that the top and bottom edges of the envelope will each display the shape $y = f(t)$, provided as mentioned the vector amplitude never falls below zero.

To carry the analysis further, some assumption must be made as to the nature of $f(t)$. An obvious choice for elementary work, is to suppose it sinusoidal. Bearing in mind that it must never become negative, the simplest form of (66) becomes

$$y = (1 + m \cos ft) \sin pt \quad \ldots \quad (66a)$$

where $m \leqslant 1$

The envelope amplitude now fluctuates between $(1 + m)$ and $(1 - m)$. (The width of the envelope varies between twice these quantities.) m is usually termed the "modulation depth." This quantity is most generally expressed as a percentage, 100 per cent. modulation corresponding to $m = 1$.

Components in Modulated Waves—Sidebands

By simple trigonometrical expansion (66a) may be re-written

$$y = \sin pt + \frac{m}{2}\sin(p + f).t$$

$$+ \frac{m}{2}\sin(p - f).t \quad \ldots\ldots\ldots \quad (66b)$$

This shows that the modulated wave of (66a) can be regarded as the sum of three distinct frequencies. The first term $\sin pt$, has a frequency equal to that of the basic wave before modulation. It is termed the "carrier." In addition there are two other terms present, of angular frequencies $(p + f)$ and $(p - f)$. These terms are called the "upper" and "lower" sidebands respectively.

These three components must not be regarded as mere mathematical abstractions—they have a definite physical existence, and the complete wave of (66a) can be synthesised by the addition of the three components indicated in (66b).

The three term modulation spectrum of (66b) is the simplest possible case, and arises only when the modulating wave is itself sinusoidal. Where, as in actual practice, the modulating wave is complex, then the modulation spectrum will contain many more components. Physically it is sufficient to remember that to every modulation frequency present in the modulating wave, two sidebands will be produced, of frequencies $(p + f)$ and $(p - f)$. This result is self-evident if we make the important postulate that the modulating system in linear*. The complex modulating wave may be analysed into its Fourier components and *each* of these components will combine with the carrier to produce the sum and difference frequencies shown in Equation (66b).

Comparison of Modulated Waves and Beat Waves.

If we examine the modulated waves shown in photos 172-173 it will be seen that they bear a striking resemblance to beat waves, as discussed in the June and August issues. In fact there are, however, important differences between a true modulated wave of the form of (66a) and a beat wave. These differences are now discussed.

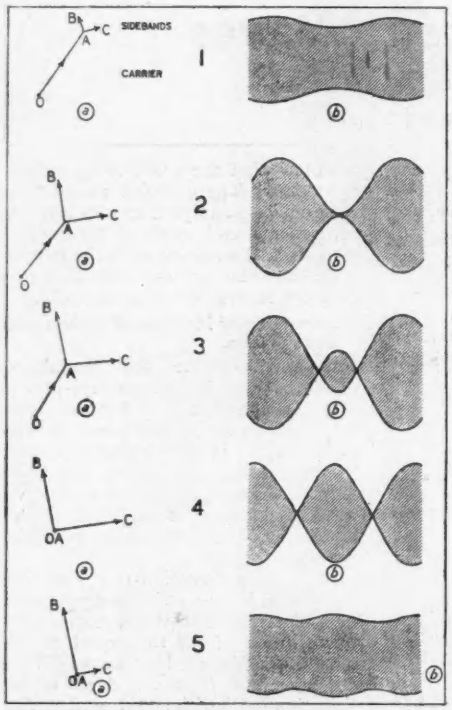
Looking at Equation (66b), we first notice that if the carrier is suppressed, then the resultant wave, formed by the addition of the two equal amplitude sidebands is a beat wave. Writing now $(p - f) = \omega$ and $2.f = \delta\omega$, Equation (66b) with suppressed carrier becomes

$$y = \frac{m}{2}\sin\omega t + \frac{m}{2}\sin(\omega + \delta\omega).t$$

which is the familiar result discussed in the August issue. The important point is that the beat wave formed by the suppression of the carrier has *twice* the beat frequency of that due to two waves of frequency difference equal to the original modulation frequency f. Physically this fact is clear—for the result of sinusoidally modulating a carrier at frequency f is to produce two sidebands of frequency *difference* equal to $2.f$.

Consider now the vector diagram representations shown in Figs. 1(a) to 5(b). Fig. 1(a) illustrates an amplitude modulated wave of the form defined by Equation (66a), while Fig. 1(b) shows the same wave displayed on a linear time scale. (Compare Photo No. 172). $\overrightarrow{OA}$ represents the

* This postulate is often rather far from the truth in practical modulating systems, especially when they are working at high modulation depths. If the modulation system is non-linear, then the sideband components cannot be obtained simply by expanding the complex modulating wave into its Fourier components and considering each component as acting alone on the carrier. The components themselves modulate each other according to the nature of the non-linearity, an effect quite beyond the scope of this account.



1. Envelope of slightly modulated wave (b) with corresponding vector diagram (a).

2. 100% modulated wave. The vector AC=AB=½OA.

3. Intersection of top and bottom halves of the envelope when the carrier is less than twice the amplitude of either side band.

4. Total suppression of carrier, giving beat wave due to interaction of upper and lower side bands.

5. Effect of attenuating one of the side bands giving a beat wave between two components of unequal amplitude.

Figs. 1-5. Types of Amplitude Modulated Wave.

carrier vector sin pt, while $\vec{AB}$ and $\vec{AC}$ are the two sidebands. As seen from (66b), |AB| = |AC| while with reference to the vector OA they rotate in opposite directions, at angular speeds of $+f$ and $-f$.

Therefore their resultant lies wholly along $\vec{OA}$. Physically this means that the effect of the modulation process has been to vary the amplitude of the wave only—there is no frequency modulation in addition. This result can be thought of as due to the essential symmetry of the sidebands with respect to the carrier—it would not occur, for example, if either sideband were distorted or suppressed. Notice that the modulation depth m is equal to 2A.B/.OA.

Figs. 2(a) and 2(b) are identical with Fig. 1, except that the modulation depth is now 100 per cent., so that here |AC| =|AB| = |OA|/2. (Compare Photo No. 173).

Figs. 3 (a) and (b) represent the interesting transition case, where the carrier amplitude |OA| has become less than twice the amplitude of either sidebands, so that $m > 1$. In this case the top and bottom halves of the complete envelope intersect each other. This means that if the resultant curve of Fig. 3(b) were rectified by a perfect half wave rectifier, which would have the effect of simply suppressing the bottom half of the complete curve, then the mean D.C. output would no longer be sinusoidal.†

Figs. 4 (a) and (b) carry the process a stage further, and indicate the result of total suppression of the carrier. The resultant is a pure beat wave due to interaction of the upper and lower sidebands. Notice that the resultant distorted wave which would be formed by perfect rectification of the beat in Fig. 4(b) has a mean fundamental component of twice the modulation frequency.

† It must not be imagined that the wave of fig. 3 (b), or the illustrative photo No. 176, generally represent what happens when a wave is over-modulated. Usually the characteristics of a modulator are such that the high frequency output falls to zero for all values of modulating voltage *beyond* that required to just reduce the carrier to zero. In other words *negative* carrier voltages are not physically realisable in most types of modulator, and the result of over-modulation appears as in photos 174 and 175

Finally, Figs. 5 (a) and (b) show the effect of attenuating one of the sidebands, so as to produce a beat wave between two components of unequal amplitude. This wave is in many respects similar to the modulated wave of Figs. 1, if the ratio of the amplitudes of the sidebands is made equal to the modulation depth m. The two important differences, however, are these. Firstly, unless the ratio between the amplitudes of the two component waves is rather large, the edge of the beat wave has an appreciable amount of harmonic distortion (August issue), whereas the edge of the modulated wave is always a pure sinusoid for all modulation depths up to 100 per cent. Secondly, the beat wave in Fig. 5 is modulated not only in amplitude, but also in frequency, whereas we saw that the modulated wave, on account of the symmetry of its sidebands, is not frequency modulated. A brief treatment of frequency modulation in beat waves is now given.

Frequency Modulation in Beat Waves

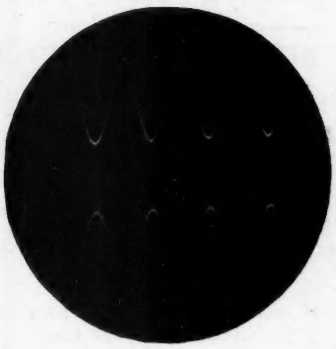
Let the two component waves in the beat be represented by vectors $\vec{OA}$ and $\vec{OB}$ in Fig. 6. Let $\vec{OB}$ represent the higher frequency component. $\vec{OC}$ is the resultant in phase and magnitude. Suppose we reduce the speed of vector $\vec{OA}$ to zero. Then with regard to $\vec{OA}$ the vector $\vec{OB}$ will describe a circular locus, and the point C will move round a circle centre A. The instantaneous phase angle of the resultant OC will be ϕ with respect to $\vec{OA}$. In one complete *beat* cycle $\vec{AC}$ will describe one complete revolution.

Fig. 7 shows the variations of ϕ throughout one complete beat cycle for various ratios of the amplitudes of the component vectors. In Fig. 7 the lower frequency component has the larger amplitude. Notice that the degree of frequency modulation tends to zero as the ratio of component wave amplitudes becomes large.

Oscillographic Examination of Modulated Waves

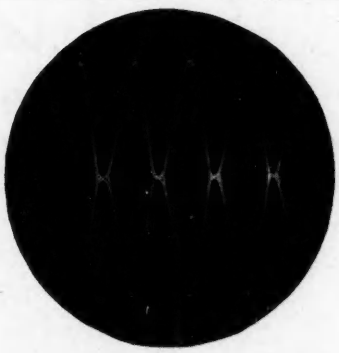
The most direct method applies to the vertical deflection plates, the modulated wave, and to the horizontal deflection plates, a linear time base synchronised to a sub-multiple of the modulation frequency. Patterns of the type shown in Photos Nos. 172 to 175 are thus obtained. If the modu-

Amplitude Modulation Patterns



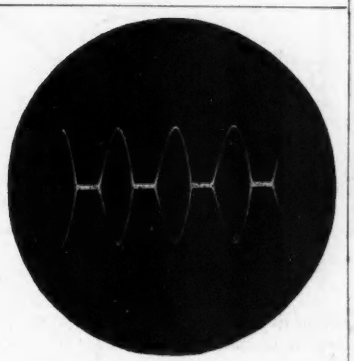
172

53 per cent. modulated wave against linear time base.



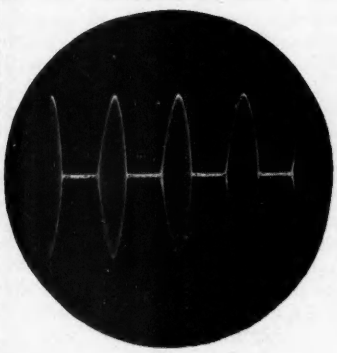
173

100 per cent. modulated wave against linear time base.



174

Over-modulated wave against linear time base. Carrier cut-off for approx. 100 degrees of modulating wave cycle.

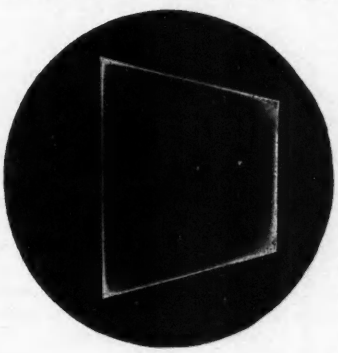


175

Over-modulated wave against linear time base. Carrier cut-off during whole of negative half cycle of modulating wave.

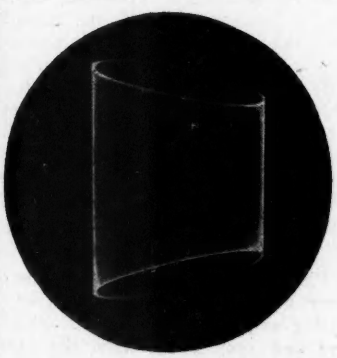
176

Special case of over-modulated wave with partial carrier suppression. See text and figs. 3.



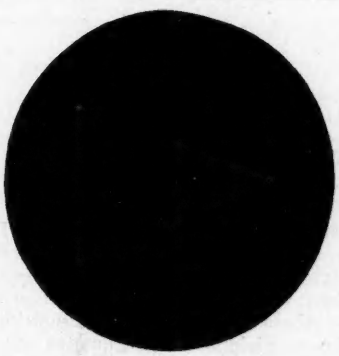
177

32 per cent. modulated wave. Cyclogram display. Linear modulation.



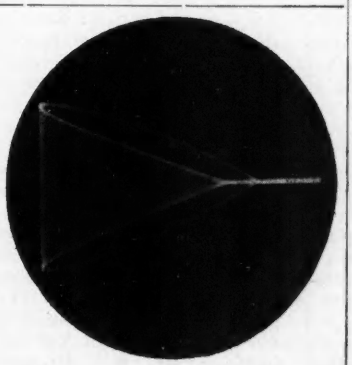
178

As 177 but with phase shift.



179

Approx. 100 per cent. modulation cyclogram. Linear modulation.



180

Over-modulation and phase shift on cyclogram display

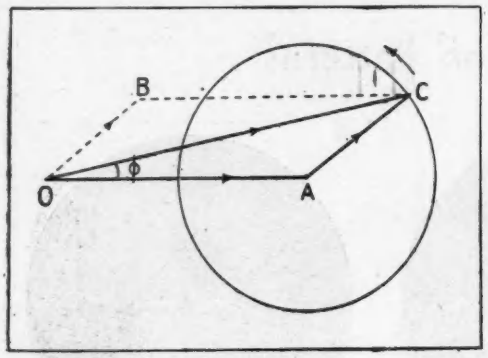


Fig. 6.

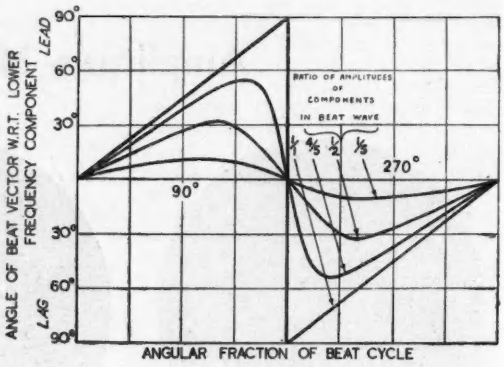


Fig. 7.

lation depth is m, then the envelope amplitude fluctuates between $(1 + m)$ and $(1 - m)$ so that m is readily found by measurement of the minimum and maximum envelope width. Over-modulation is indicated by patterns of the type shown in Photos Nos. 174 and 175, where it will be seen that the carrier amplitude has been reduced to zero for an appreciable fraction of the cycle of the modulating wave.

Examination by use of the Cyclogram

Throughout these articles, stress has been laid on the many advantages which can often be obtained in cathode ray oscillography, by departing from the use of linear or quasi-linear time bases for display, and using instead presentations of the cyclogram type. By cyclogram display is meant merely the use of the existing potentials present in the circuit under investigation to provide the deflection voltages for the cathode ray tube. The definition is intended to cover the case where the existing potentials are amplified, or undergo phase shifting before application to the deflector plates, but not, of course, the case where these potentials are used to trigger or synchronise time bases which generate new wave forms. The Lissajous figure is perhaps the most important type of cyclogram display, and was treated at length at the beginning of this series because of its value as a technique for the examination of frequency and phase. The present problem of the examination of modulation patterns affords yet another instance of the frequent superiority of the cyclogram technique over that employing the use of linear time bases.

The "modulation cyclogram" is obtained by applying to one axis of the cathode ray tube the complete modulated wave, and to the other axis the modulating wave itself. Thus in parametric form the equations defining the spot locus are:

$$y = (1 + m \cos ft)\sin pt \quad \ldots\ldots \quad (66a)$$

$$x = A \cos ft \quad \ldots\ldots \quad (67)$$

Eliminating cos ft yields

$$y = \left(1 + m.\frac{x}{A}\right)\sin pt \quad \ldots\ldots \quad (68)$$

Now x varies between the limits $\pm A$, so that from (68) it is clear that the amplitude of sin pt varies between $(1 - m)$ and $(1 + m)$. Furthermore, (68) shows a linear relationship between x and y. If, therefore, as is usual, $p >> f$, it follows that the pattern obtained is a "solid" trapezium, the parallel sides of which represent lengths of $(1 - m)$ and $(1 + m)$. This pattern is shown in Photo No. 177 for the special case where $m = 0.32$, *i.e.*, the modulation depth is 32 per cent.

If the modulation system is distortionless, then the non-parallel sides of the trapezoidal shaped figure are straight lines, as is evident from (68). It is particularly important to note that this result holds even if the modulating wave is non-sinusoidal, and has any arbitrary form $f(t)$‡. It is necessary and sufficient that this same form $f(t)$ appears both in Equations (66a) and (67), so that it may be eliminated by direct cross substitution to yield a linear Equation (68). In a distortionless modulator this must automatically obtain provided that the modulating wave undergoes no distortion or phase shift in the wiring to the cathode ray tube deflector plates.

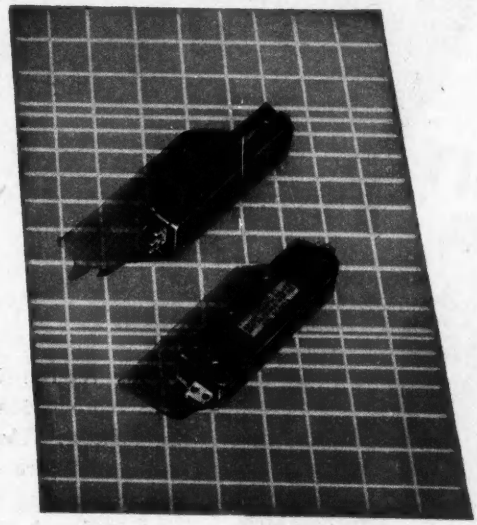
‡ More precisely, $f(t)$ is restricted only by the condition $mf(t) > -1$

As a test for modulator linearity, therefore, the cyclogram technique is markedly superior to that using a time base, since in this latter case linearity is shown by the identity of the modulating waveform and the envelope edge—a comparison which it is not very easy to make with accuracy, and is certainly far more difficult than simply observing the departure of the edge of the trapezoidal figure from straightness. Furthermore, the cyclogram technique requires no time base, and provides automatic rigid locking of the pattern so that no synchronising is required.

Photo No. 178 shows the result of a phase shift between the modulating voltage and that applied to the "X" axis of the C.R.T. The actual modulation is linear, so that the straight line joining the ends of the parallel lines divides the ellipses symmetrically. The presence of such a phase shift, however, makes the assessment of the degree of linearity appreciably more difficult and in practice it is advisable to include a simple R-C phase shifting network between the C.R.T. and the source of modulating voltage so that it may be eliminated.

Photo No. 180 shows the results of over modulation as it appears on a cyclogram, as compared with Photos 174 and 175, which show the same effect on a linear time base display. Phase shift is also present in Photo No. 180.

Record Cutters



Licensed by Brush Crystals Co., Ltd.

acos

Record Cutter Mod. RH-1. Substantially uniform response 50-9,000 cps. Recommended input: Constant amplitude recording 50 volts maximum swing on RMS meter. Constant velocity recording 150 volts maximum swing on RMS meter. Suitable for operation from most domestic radio receivers. List price Gt. Britain, £6.6.0

acos products combine the reliability of Brush crystals with the experience in manufacture and design of

COSMOCORD LTD · ENFIELD · MIDDX · ENGLAND

FIT ROLA AND RELAX

A radio receiver is judged by the quality of its reproduction more than by any other single factor. That is why the speaker is such a vital part of any set. No wonder so many Planning Engineers decide on Rola speakers for all their models. They know they can fit Rola and relax!

ROLA SPEAKERS
THEIR QUALITY SPEAKS FOR ITSELF

BRITISH ROLA LTD GEORGIAN HOUSE · BURY ST · ST JAMES'S · LONDON. S.W.1

The Transient Response of a Tuned Circuit

By D. G. TUCKER, Ph.D., A.M.I.E.E.*

ALTHOUGH the response of a tuned circuit to suddenly applied signals is referred to in many books, and worked out for some cases in several of them, yet there does not seem to be any really adequate treatment available. In view of the importance of the subject, and the fact that important features of the response are often overlooked, even in published work, a fairly comprehensive summary of the performance of a tuned circuit is given in this article.

A tuned circuit may be a series or a parallel combination of inductance (L) and capacitance (C). The losses in the circuit are most conveniently represented by a series resistance in the series case, and by a shunt resistance in the parallel case. The analysis of the two circuit arrangements is the same except for the interchange of current and voltage functions and for the shift of certain phase values by $\pi/2$ rads. The following work refers, therefore, to a parallel combination of L, C and R, with a "constant-current" external circuit. For a given e.m.f. applied to the external circuit, the resultant current through the combination of L, C and R is constant, independent of frequency and time. Then if an instantaneous p.d. of value e is developed across the tuned circuit, the general differential equation is:

$$\frac{e}{R} + \frac{1}{L}\int e\,dt + C\frac{de}{dt} + B = i \qquad \ldots\ldots\ldots\ldots (1)$$

But we will assume $B = 0$, *i.e.*, there is no current independent of e, *i.e.*,

$$\frac{d^2e}{dt^2} + \frac{1}{RC}\cdot\frac{de}{dt} + \frac{1}{LC}\cdot e = \frac{1}{C}\cdot\frac{di}{dt} \qquad (2)$$

by differentiating and regrouping. The solution of this equation for some of the cases which arise in practice is dealt with to a certain extent in several textbooks, the best treatment being by Guillemin[1]; thus only the minimum of working is given here.

1. D.C. Applied Signal

If a D.C. current passes through the circuit, then at any time, $di/dt = 0$. $\therefore$ (2) becomes

$$\frac{d^2e}{dt^2} + \frac{1}{RC}\cdot\frac{de}{dt} + \frac{1}{LC}\cdot e = 0 \qquad \ldots\ldots (3)$$

Three distinct forms of solution are possible according to the relation of LC to $4R^2C^2$.

(a) If $4R^2C^2 > LC$, an oscillatory p.d. is obtained.

$$e = (\exp.(-\beta t))\ (A\cos\omega_o t + B\sin\omega_o t)^* \qquad (4)$$

where $\beta = \frac{1}{2RC}$ and $\omega_o = \sqrt{\frac{1}{LC} - \frac{1}{4R^2C^2}}$

A and B are constants determined by the initial conditions. For instance, if the current has a magnitude I at time $t > 0$, and is zero prior to that, we have as initial conditions,

for $t = 0$, that $e = 0$ and $\frac{de}{dt} = \frac{I}{C}$

(by considering the condenser). This gives $A = 0$, $B = I/\omega_o C$ by applying the conditions to Equation (4).

(b) If $LC > 4R^2C^2$, a non-oscillatory p.d. is obtained:

$$e = A(\exp.(-\beta_1 t)) + B(\exp.(-\beta_2 t)) \qquad (5)$$

where $\beta_1 = \frac{1}{2RC} - \sqrt{\frac{1}{4R^2C^2} - \frac{1}{LC}}$

and $\beta_2 = \frac{1}{2RC} + \sqrt{\frac{1}{4R^2C^2} - \frac{1}{LC}}$

and if, as before, current $= I$ for $t > 0$ and zero for $t < 0$,

$$A = -B = \frac{I}{2C\sqrt{\frac{1}{4R^2C^2} - \frac{1}{LC}}}$$

(c) If $LC = 4R^2C^2$, the circuit is said to be critically damped, and

$$e = (\exp.(-\beta t))(A + Bt)$$

where $\beta = 1/2RC$.

For the same conditions as before we have:

$$A = 0,\ B = I/C$$

* $\exp.(-\beta t) = \epsilon^{-\beta t}$

2. A.C. Applied Signal

If $i = I_m\sin(\omega t + \alpha)$ where I_m, ω and α are constants, then $\frac{di}{dt} = \omega I_m\cos(\omega t + \alpha)$ and, for any time t, Equation (2) becomes

$$\frac{d^2e}{dt^2} + \frac{1}{RC}\cdot\frac{de}{dt} + \frac{1}{LC}\cdot e = \frac{\omega I_m}{C}\cos(\omega t + \alpha) \qquad \ldots\ldots\ldots\ldots (7)$$

The solution of this must always contain the steady-state term:

$$e = I_m\,|\,Z\,|\sin(\omega t + \alpha - \phi) \qquad \ldots (8)$$

where $|\,Z\,|$ = modulus of impedance of tuned circuit at the applied angular frequency,

and ϕ = phase angle of this impedance.

There must be, in addition, a transient term identical in form with (4), (5) or (6), according as $4R^2C^2$ is greater than, equal to, or less than LC. The values of A and B will be different. In practice, the only condition likely to be encountered is that giving an oscillatory transient, *i.e.*, $4R^2C^2 > LC$, and so only this case will be considered. Thus for $4R^2C^2 > LC$, the complete solution of (7) is:

$$e = (\exp.(-\beta t))(A\cos\omega_o t + B\sin\omega_o t) + I_m\,|\,Z\,|\sin(\omega t + \alpha - \phi) \qquad \ldots (9)$$

where A and B are determined by the values of e and $\frac{de}{dt}$ at time $t = 0$.

Note that ω_o is the natural frequency of the tuned circuit; but for the sake of simplicity it is also taken as the frequency of maximum response, *i.e.*, $1/\sqrt{LC}$, where $4R^2C^2 \gg LC$.

If we consider an A.C. wave suddenly applied at $t = 0$ with an initial phase angle α, we can deduce that

$$A = -I_m\,|\,Z\,|\sin(\alpha - \phi) \qquad \ldots (10)$$

and $B = \frac{I_m}{\omega_o}\left[\frac{1}{C}\sin\alpha - \ldots\ldots (11)\right.$

$$\left. |\,Z\,|\left\{\omega\cos(\alpha - \phi) + \beta\sin(\alpha - \phi)\right\}\right]$$

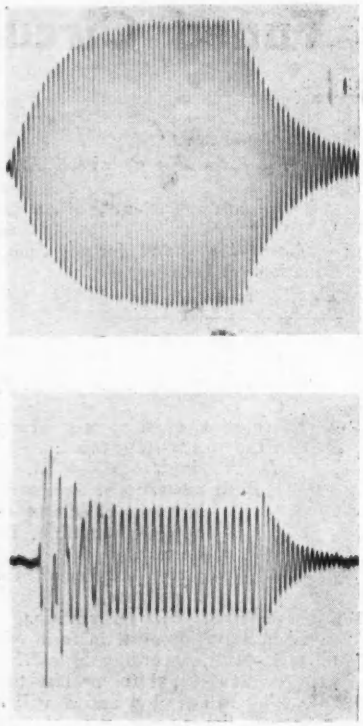
Thus it is evident that the coefficients of the transient terms depend on the initial phase angle. It is useful to consider four cases, which represent sufficiently the whole behaviour

---

* P.O. Research Station.

[1] E. A. Guillemin, "Communication Networks," Vol. I, p. 92 onwards. (John Wiley, 1931.)

OSCILLOGRAMS



a b c d

Fig. 3. For these oscillograms the tuned circuit had a resonant frequency of 800 c/s. The duration of each pulse was 50 mS.

(a) Applied frequency=800 c/s (i.e., resonant frequency) Q=40.

(b) Applied frequency=900 c/s. Q=40.

(c) Applied frequency=500 c/s. Q=15.

(d) Applied frequency=50 c/s. Q=15.

of the circuit, for most purposes.

(a) $\alpha = 0$, $\omega = \omega_0$.

Here $\phi = 0$, $A = 0$, $B = -I_m Z_0$ where $Z_0 = |Z|$ at freq. ω_0
$= R$

$$\therefore e = I_m R(1 - \exp.(-\beta t))\sin\omega_0 t \quad (12)$$

(b) $\alpha = 0$, ω *not very close to* ω_0.

Here $\phi \approx \pm \pi/2$, $A \approx \pm I_m |Z|$, $B \approx \pm I_m |Z| \beta/\omega_0$.

Now $\beta/\omega_0 < 1$ and we have therefore that B may be neglected, as a first approximation, compared with A.

$$\therefore e \approx \pm I_m|Z|[\cos\omega t - (\exp.(-\beta t))\cos\omega_0 t] \quad (13)$$

(c) $\alpha = \pi/2$, $\omega = \omega_0$.

Here $\phi = 0$, $A = -I_m R$, $B = \frac{I_m R}{2Q}$ or $\frac{I_m}{2\omega_0 C}$

Thus $B < A$, and

$$e \approx I_m R(1 - \exp.(-\beta t))\cos\omega_0 t \quad (14)$$

(d) $\alpha = \pi/2$, ω *not very close to* ω_0.

Here $\phi \approx \pm \pi/2$, $A \approx 0$,

$$B = I_m |Z| \left(\left| \frac{\omega_0}{\omega} - \frac{\omega}{\omega_0} \right| \mp \frac{\omega}{\omega_0} \right)$$

It is necessary here to observe that according to the conventions adopted, ϕ is negative for $\omega < \omega_0$ and positive for $\omega > \omega_0$.

$$\therefore \text{For } \omega < \omega_0,\ B = I_m |Z| \left(\frac{\omega_0}{\omega}\right)$$

$$\text{and for } \omega > \omega_0\ B = -I_m |Z| \left(\frac{\omega_0}{\omega}\right)$$

$$\text{since} \left| \frac{\omega_0}{\omega} - \frac{\omega}{\omega_0} \right| = \frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}$$

$$\therefore e \approx \pm I_m |Z| [\sin\omega t - (\exp.(-\beta t)) \frac{\omega_0}{\omega} \sin\omega_0 t] \quad (15)$$

3. Conclusions Regarding the Suddenly Applied A.C. Signal.

(a) We see from Equations (12) and (14) that when the applied frequency is equal to the natural frequency, the build-up envelope function is:

$$1 - \exp.(-\beta t) \quad (16)$$

This result is illustrated in Oscillogram No. 1 and it is evident, too, that the decay function is $\exp.(-\beta t)$.

(b) From Equations (13) and (15) we see that when the applied frequency is not equal to the natural frequency, the magnitude of the transient term is very dependent on the initial phase angle. When the initial phase angle is zero, the transient peak amplitude is equal to the steady-state amplitude. When the initial phase angle is $\pi/2$, the transient-peak/steady-state ratio varies with frequency according to the expression:

$$\text{ratio} = \omega_0/\omega \quad (17)$$

Fig. 1 shows this effect; it actually considers the maximum transient peak at any frequency; below resonance this occurs with $\alpha = \pm \pi/2$ and above resonance with $\alpha = 0$ or π. Oscillograms 2 to 4 show some actual observed waveforms, for the cases where $\omega \neq \omega_0$. It will be seen how the transient and steady-state waves phase in and out. The maximum total voltage is evidently very nearly equal to the sum of transient-peak and steady-state voltages, provided ω is appreciably different from ω_0. But at $t = 0$, the transient and steady-state voltages always oppose one another, so that if the frequency difference is small, the maximum

voltage barely exceeds the steady-state voltage.

The frequency response to steady-state signals is given in the Appendix.

4. The Current in the Inductance.

It may happen that the current functions in the inductance require to be known. Actually, this is less likely than the corresponding case of the voltage functions of the condenser in a series-tuned circuit. But the expressions given below apply equally to both cases, except that for the voltage across the condenser, I_m must be replaced by E_m and i_L by E_c, with the initial phase angle α changed by $\pi/2$ rads.

Let i_L be the current in the inductance, then for the cases considered before we have:

(a) $\alpha = 0$, $\omega = \omega_o$.

$$e = I_m R(1 - \exp.(-\beta t))\sin\omega_o t$$

$$\therefore i_L = \frac{1}{L}\int e\,dt$$

$$= \frac{I_m R}{L}\left[-\frac{1}{\omega_o}\cos\omega_o t + \frac{\exp.(-\beta t)}{\sqrt{\omega_o^2 + \beta^2}}\cos(\omega_o t - \theta)\right]$$

where $\theta = \tan^{-1}\dfrac{\beta}{\omega_o} \approx 0$,

$$i.e.,\ i_L \approx \frac{-I_m R}{\omega_o L}\left(1 - \exp.(-\beta t)\right)\cos\omega_o t \quad \ldots\ldots\ldots (18)$$

(b) $\alpha = 0$, ω *not very close to* ω_o.

$$e = I_m |Z|[\cos\omega t - \exp.(-\beta t))\cos\omega_o t]$$

$$\therefore i_L = \frac{I_m |Z|}{L}\left[\frac{1}{\omega}\sin\omega t + \frac{\exp.(-\beta t)}{\sqrt{\omega_o^2 + \beta^2}}\sin(\omega_o t - \theta)\right]$$

$$i.e.,\ i_L \approx \frac{I_m}{1 - \left(\dfrac{\omega}{\omega_o}\right)^2}\left[\sin\omega t + \frac{\omega}{\omega_o}\exp.(-\beta t)\sin\omega_o t\right] \quad \ldots\ldots\ldots (19)$$

(c) $\alpha = \pi/2$, $\omega = \omega_o$.

$$i_L \approx \frac{I_m R}{\omega_o L}\left(1 + \exp.(-\beta t)\sin\omega_o t\right) \quad (20)$$

(d) $\alpha = \pi/2$, ω *not very close to* ω_o

$$i_L \approx \frac{-I_m}{1 - \left(\dfrac{\omega}{\omega_o}\right)^2}\left[\cos\omega t - \exp.(-\beta t)\cos\omega_o t\right] \quad \ldots\ldots\ldots (21)$$

It is thus clear that the current in the inductance (and the voltage across the condenser in a series-tuned circuit) has no transient component larger than the steady-state component, except in case (b) when $\omega > \omega_o$.

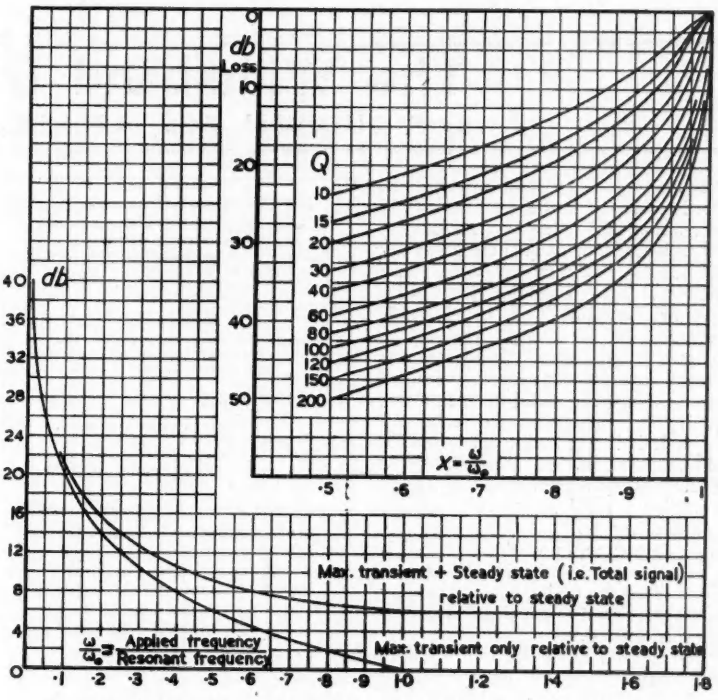


Fig. 1. Maximum transient / steady-state voltage ratio plotted against frequency.

Fig. 2 (top right). The steady-state amplitude response of a tuned circuit with constant current excitation.

APPENDIX

The Steady-state Amplitude Response of a Tuned Circuit

A parallel connexion of L, C and R gives an impedance

$$Z = R \cdot \frac{1}{1 + j\dfrac{R}{\omega L}(1 - x^2)} \quad \ldots\ldots (1)$$

where $x = \omega/\omega_o$

(1) *If Q is constant* with frequency, which is the normal case,

$R = Q\omega L$

$$\therefore Z = Q\omega L \cdot \frac{1}{1 + jQ(1 - x^2)}$$

or volts ratio (rel. to resonance) in constant current circuit

$$= x\,\frac{1}{1 + Q^2(1 - x^2)^2}$$

giving a modulus $= \dfrac{x}{\sqrt{1 + Q^2(1 - x^2)^2}}$ (2)

This modulus has been plotted in Fig. 2 for values of x between 0.5 and 1.0 and for Qs between 10 and 200. The characteristic is not quite symmetrical, and in reading attenuations at frequency $1/x$ instead of x, errors will be introduced (near resonance only) of a fraction of a decibel. (2) *If R is constant*, which is most unlikely in practice,

$R = Q_o\omega_o L$ (Q_o and ω_o are values at resonance)

$$\therefore Z = R \cdot \frac{1}{1 + jQ_o((1/x) - x)}$$

$$\text{or volts ratio} = \frac{1}{1 + Q_o^2((1/x) - x)^2}$$

giving a modulus

$$= 1/\sqrt{1 + Q_o^2((1/x) - x)^2} \quad \ldots\ldots\ldots (3)$$

Although less practical, this has the advantage of being symmetrical about resonance.

Note that *in both cases*, when x is sufficiently different from unity for $Q^2(1 - x^2)^2 >> 1$ or $Q_o^2((1/x) - x)^2 >> 1$ we obtain

Modulus of voltage ratio $= 1/Q_o((1/x) - x)$ ..... (4)

Thus, it is clear that the lack of symmetry in (1) occurs near resonance only.

The Wide-band Dipole

By F. DUERDEN, B.Sc., A.M.I.E.E., M.I.R.E.

IN many modern radio applications it is essential that the aerial should function satisfactorily over a considerable band of frequencies, and not at a single frequency only. In radar and television, where signals of pulse type are employed, a considerable spectrum of sidebands has to be accommodated, in addition to the carrier. In frequency modulated transmissions, the aerial must function equally well throughout the frequency sweep, if it is not to introduce amplitude modulation. In a normal communications system, where it is desired to employ several alternative carriers by switching without modifying the aerial each time, or where an aerial is to be mass produced when the transmitter frequency is not accurately known, an aerial of considerable bandwidth is needed.

The method normally employed to increase the bandwidth of a cylindrical dipole is simply to increase its diameter. By this means the reactance of the aerial (which varies rapidly with frequency) is reduced, while the radiation resistance (in the case of the usual half-wave dipole) is affected only slightly. The problem then arises—what increase in diameter is necessary to provide a given bandwidth? This question will be dealt with here: (a) by calculation of the bandwidth of the dipole itself; (b) by a consideration of the more stringent conditions introduced when the dipole is connected to a long feeder, which is usually the case. Both treatments will be approximate in view of the great complexity of exact solutions, but it is believed that the results will be sufficiently accurate for the majority of applications.

It may be noted that, for a given weight of metal in the aerial, a cylinder does not give the optimum bandwidth.[1] Some further improvement may be produced by arranging that the greatest surface area of conductor occurs where the current in the aerial is greatest, leading to an aerial of curved profile. Narrow and wide band cylindrical aerials, and a wide-band shaped dipole are shown in Figs. 1 (a), (b) and (c) respectively. The calculation of such shaped dipoles is difficult and will not be attempted here. The results for the cylindrical aerial may be used as a guide to the diameter of shaped aerial required. Design from that point is normally a matter of fairly simple experiment[2].

List of Symbols and Abbreviations

θ	= Electrical length of line or aerial.
Z_o	= Characteristic impedance of line.
Z_{oa}	= Characteristic impedance of aerial
Zd	= Impedance at centre of aerial.
l	= Length of aerial centre to tip.
d	= Diameter of aerial.
λ	= Wavelength.
c	= Velocity of light.
f	= Frequency being considered.
fo	= Resonant frequency.
fi	= Frequency at edge of band.
ω	= $2\pi f$.
X	= Reactance of aerial or equivalent circuit.
R_r	= Radiation resistance of aerial.
BW	= Bandwidth.
S.W.R.	= Standing wave ratio.
n	= Any number, value chosen as in text.

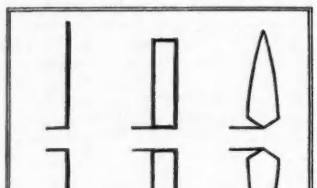


Fig. 1. Narrow and wide cylindrical and shaped dipoles.

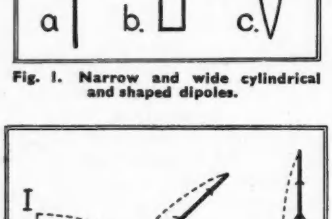


Fig. 2. Development of dipole by opening out a line (current standing wave shown)

Bandwidth of Dipole Only

A dipole may be considered as developed from a length of open-circuited transmission line[3], by opening out the line (see Fig. 2). In each case a wave, starting out from the feedpoint of the line or aerial, will be reflected at the open-circuit, and set up a standing wave. The principal difference is that, in the case of the aerial, power is being radiated into space, and, since there is this power loss, the aerial impedance must have a resistive component. The aerial may be represented by the equivalent circuit shown in Fig. 3 (a), where X, the reactance of a length of open-circuited line of electrical length θ, is equal to $Z_{oa}\cot\theta$, (θ being $2\pi l/\lambda$ or $2\pi fl/c$). The way in which this reactance varies with frequency (a tangent curve) is shown in Fig. 3 (b), curve X.[3] The impedance variation of the whole circuit, taking R also into account, is shown in the curve $Z\ (=\sqrt{R^2+X^2})$.

The shape of the curve will depend upon the value of Z_o for the aerial. If Z_{oa} is low the curve will be flat; if Z_{oa} is high it will be sharply peaked. The relationship between Z_{oa} and the dimensions of the aerial is shown in Fig. 4.[1, 2, 3] Hence the curve of impedance variation with frequency can be plotted for an aerial of known dimensions.

In considering the bandwidth of the aerial, it is necessary to establish some criterion of performance, and that usually employed is obtained from tuned circuit theory, where the limits of the band are taken as those frequencies at which the response of the circuit is reduced to $1/\sqrt{2}$ of maximum. If, in a series LCR circuit, the current at resonance is I, the power at resonance is RI^2. At the limits of the band the current is $I/\sqrt{2}$ and the real power $R(I/\sqrt{2})^2 = \frac{1}{2}RI^2$. The limits of the band are therefore those frequencies at which the real power is reduced to half. Applying this standard to the aerial, in Fig. 5 we have the generator matched to the aerial at resonance, since $Z_g = R_r$, but at other frequencies the reactance X will appear, reducing the power in the aerial. When the power is reduced to half, the frequency deviation from resonance (*i.e.*, the half-bandwidth) is given by

$$\frac{\frac{1}{2}BW}{f_o} = \frac{4R_r}{\pi Z_{oa}}$$

This expression is derived in appendix A. The variation of R_r with frequency is assumed negligible compared to the reactance variations. Since Z_{oa} is a function of the aerial dimensions, the bandwidth may be

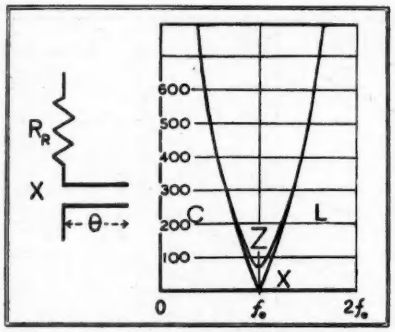


Fig 3. (a) Equivalent circuit of dipole. (b) Variation of its reactance and impedance with frequency.

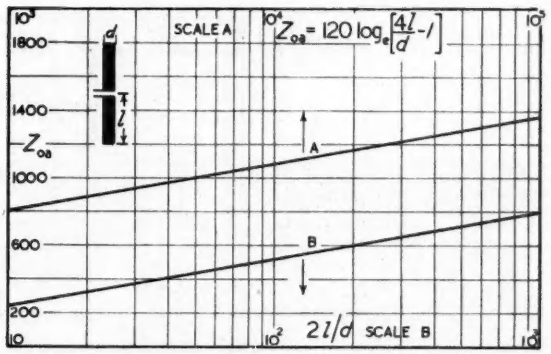


Fig 4. Variation of characteristic impedance with dipole dimensions.

plotted against the aerial dimensions as in Fig. 6.

As an example of the use of this curve, consider a half-wave dipole, to operate at 300 Mc/s. (wavelength = 1 metre), made from $\frac{3}{8}$ in. diameter tube. l, the centre-to-tip length of the dipole, is $\lambda/4$, which is 9.85 in. The ratio l/d is therefore 9.85.8/3 = 26.2, and Fig. 6 gives the corresponding bandwidth at 21 per cent. of 300 Mc/s., or 62 Mc/s. The aerial should therefore function from 238 Mc/s to 362 Mc/s.

Bandwidth of Dipole and Feeder

The result obtained above will be regarded as surprising in the light of practical experience, since we are accustomed to obtaining satisfactory performance over a very much smaller bandwidth for aerials of similar dimensions. The reason for this is that normally the aerial will be connected at the end of a long feeder line, and it is not the bandwidth of the aerial itself but the mismatch between aerial and feeder which first sets a limit to the bandwidth. In the above example, if the aerial were matched to the feeder at 300 Mc/s. there would be a standing wave ratio of about 6 : 1 at 362 Mc/s! [Considering the transmitting case, *i.e.*, when the aerial is the *load* on the line, and not the generator.]

We are therefore faced with the problem of finding the way in which the mismatch varies with frequency. This is done by deciding what standing wave ratio may be tolerated and finding the value of X (*see* Fig. 5), which will produce this standing wave on a line whose $Z_o = R_r$, variations in R_r being neglected. Since $X = Z_{oa} \cot\theta$, the value of θ giving the limiting value of X may be found, and this θ will be the electrical length of the dipole at the edge of the band. The ratio of this θ to 90° (the value of θ at f_o) is the same as the ratio f_1/f_o where f_1 is the frequency at the edge of the band. The bandwidth can therefore be obtained. This is calculated in Appendix B and the result obtained is that

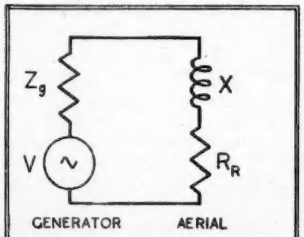
$$\frac{\frac{1}{2}BW}{f_o} = \frac{2nR_r}{\pi Z_{oa}}$$

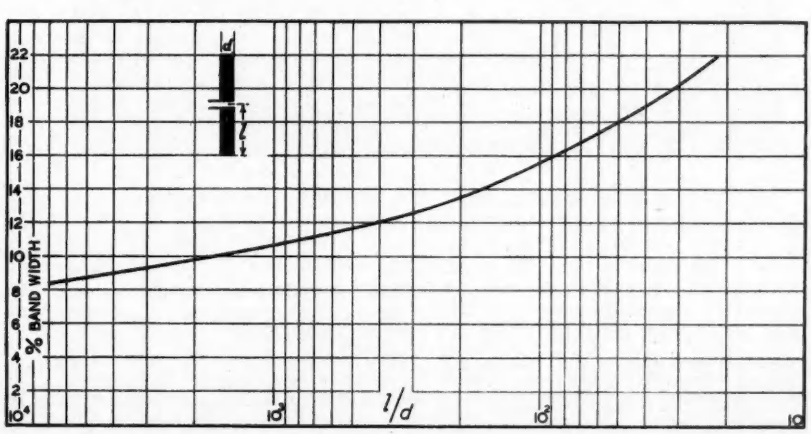
where $X = nR_r$ is the limiting value of X specified. The relationship between X (and therefore n) and the S.W.R. may be obtained from the transmission line equations, remembering that Z_o for the line equals R_r if line and aerial are matched at resonance. More usually the calculation will be made by a circle diagram calculator (*see* bibliography).[5, 6]

From the above formula and Fig. 4, curves may be plotted of bandwidth against aerial dimension for various values of n, *i.e.*, for various permissible standing wave ratios. A set of these curves is given in Fig. 7. As an example of their use, say the dipole of the previous example is matched to a feeder at resonance (*i.e.*, Z_o of the line is 73 ohms). The

Fig. 5 (below). Equivalent circuit of dipole fed by generator (or from line).

Fig. 6 (right). Variation of bandwidth (expressed as % of f_o) with dimensions, for dipole alone.





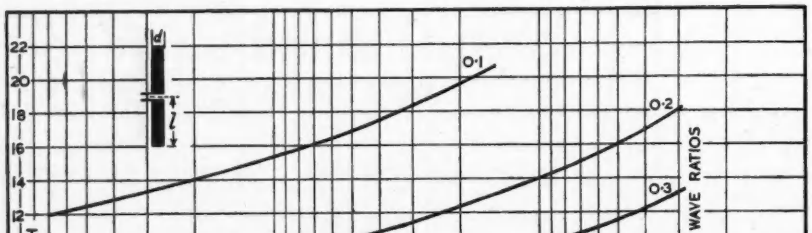


Fig. 7. Variation of bandwidth with dipole dimensions (dipole and feeder) for various permissible standing wave ratios on feeder.

maximum permissible S.W.R. is to be 1.5 : 1, or 1 : 0.66. Estimate the 0.66 S.W.R. curve between the 0.6 and 0.7 curves and find the bandwidth corresponding to $l/d = 26.2$. This gives 4.4 per cent. and the dipole would therefore function from 286.8 to 313.2 Mc/s without exceeding this S.W.R.

It will be seen that, for most applications, the mismatch to the line sets a limit to the bandwidth, rather than the Q of the dipole itself.* The curves of Fig. 7 should therefore be of wider application than that of Fig. 6.

Appendix A

(i) Compare the impedance of the dipole equivalent circuit, shown in Fig. 3(a), with that of a series *LCR* circuit.[8]

For the *LCR circuit*:

$$Z' = R' + jX$$
$$= R + j(L\omega - 1/C\omega)$$
$$= R + jL\omega[\omega^2 - \omega_o^2)/\omega^2]$$

since $\omega_o = 1/\sqrt{LC}$ or $C = 1/L\omega_o^2$

For the dipole circuit:

$$Z_D = R + jX_A$$
$$= R - jZ_{oa}\cot\theta$$
$$= R - jZ_{oa}\cot(\omega l/c)$$
$$= R - jZ_{oa}\tan(\pi/2 - \omega l/c)$$
$$= R - jZ_{oa}(\pi/2 - \omega l/c) \text{ approx.}$$

Now fit the two curves of reactance against frequency together by choosing a value of L which will give both curves the same slope near the resonant frequency, *i.e.*, the value of L making the dipole and *LCR* circuits equivalent near f_o.

Differentiating with respect to ω therefore,

$$dX_A = jZ_{oa}l/c$$

At resonance $l = \lambda/4 = c/4f_o = \pi c/2\omega_o$

$$dX_A/d\omega = jZ_{oa}\pi/2\omega_o$$

$$dX/d\omega = jL(1 + \omega_o^2/\omega^2)$$

At resonance $\omega = \omega_o$ $dX/d\omega = j2L$

If the two slopes are equal,

$$L = \pi Z_{oa}/4\omega_o$$

Now in a tuned circuit $Q = L\omega_o/R$ and the half bandwidth (from f_o to $1/\sqrt{2}$ of max. response) is f_o/Q

$$\text{or } \tfrac{1}{2}BW = R/L\omega_o = \frac{4R}{\pi Z_{oa}}.f_o,$$

which gives the required formula.

(ii) The above result may be obtained rather more simply than by the standard method given in (i) by considering the equivalent circuit of Fig. 5. In this, the power in R will be reduced to half when X reaches a value of $2R$, since I will fall as X increases. Hence $X = 2R$ becomes the condition for the limit of the band.

Using the same approximation as in (i), $X = Z_{oa}(\pi/2 - \omega l/c)$ so that $Z_{oa}(\pi/2 - \omega l/c) = 2R$ at the limit of the band. As above, $l = \pi c/2\omega_o$ since $l = \lambda/4$ at the resonant frequency.

Then $Z_{oa}(\pi/2 - \pi\omega/2\omega_o) = 2R$

$$1 - \omega/\omega_o = 4R/Z_o\pi.$$

But $1 - \omega/\omega_o = (\omega_o - \omega)/\omega_o$

$= (f_o - f)/f_o =$ the half bandwidth$/f_o$

$$\tfrac{1}{2}BW/f_o = 4R/\pi Z_{oa} \text{ as in (i).}$$

The two solutions indicate that the approximations involved in (i) and (ii) are rather better than might be expected since the same value of X makes the curves, for dipole and equivalent circuit, fit around f_o in (i) and at the limit of the band in (ii).

Appendix B

The dipole is matched to the line at f_o where the dipole impedance is a pure resistance of $R = 73$ ohms.

Say $X = nR$ gives the standing wave ratio which can just be tolerated on the line. The conversion from X to S.W.R. is best done by means of the circle diagram, from which the S.W.R.'s, corresponding to $R + jnR$ for various values of n, can be read off. In this case $R = Z_o$ of the line since the two are matched at resonance. The calculation now proceeds as in A (ii) except that the condition is $X = nR$ in place of $X = 2R$. The result will then be $\frac{1}{2}BW = 2nR/\pi Z_{oa}$.

The relationship between n and the S.W.R. is given in the following table:

S.W.R.	n	S.W.R.	n
.9	.1	.4	.95
.8	.2	.3	1.3
.7	.38	.2	1.8
.6	.5	.1	2.9
.5	.7		

References

[1] Schelkunoff: "Theory of Aerials of Arbitrary Size and Shape." *Proc. I.R.E.* Sept. 1941.—Calculation of *Zo Rr* and *X* for dipoles of various shapes.

[2] Schelkunoff: "On Radiation from Antennas." *Proc. I.R.E.*, Nov. 1942.—Development of dipole from line and critical analysis of the method.

[3] Herold & Malter: "Radio Reception at UHF." *Proc. I.R.E.*, Aug. 1943.—*Zo*, bandwidth, equivalent circuit, *Q* of dipole at its own terminals.

[4] Brown & Woodward: "Cylindrical Antenna Impedance." *Proc. I.R.E.*, April 1945.—Experimental measurements of *Rr* and X for aerials of various diameters.

[5] Willis Jackson "High Frequency Transmission Lines." (Methuen 1945).—Chap. 6—The circle diagram.

[6] Smith: "An Improved Transmission Line Calculator." *Electronics*, Jan. 1945.—The Circle Diagram.

[7] *Electronic Engineering*, Data Sheets, 59-62: "Thin Cylindrical Aerials." Feb. 1944.—*Zo*, *Rr*, *X* for thin cylinders.

[8] Ladner & Stoner: "Short Wave Wireless Communication." (Chapman & Hall, 1942).—Chap. 7. —Aerials.—L.C.R. of aerial from line development.

[9] Terman: "Radio Engineering Handbook." (McGraw Hill, 1943).—Section 11.—General aerial theory; wide band aerial graphs.

* The principle exception to this is the case of a receiving aerial when the feeder is perfectly matched to the receiver as load, as there can then be no standing wave on the line, whatever the aerial impedance.

The Ion Trap in C. R. Tubes

By J. SHARPE B.Sc.*

IN all types of cathode-ray tube, it is found that the electron beam is accompanied by negative ions of various types. In a continuously pumped cold cathode tube the ions are, of course, formed in the gas discharge. In a high vacuum, sealed off tube there is evidence that the majority of the ions are derived from the oxide coating.[1, 2, 3]

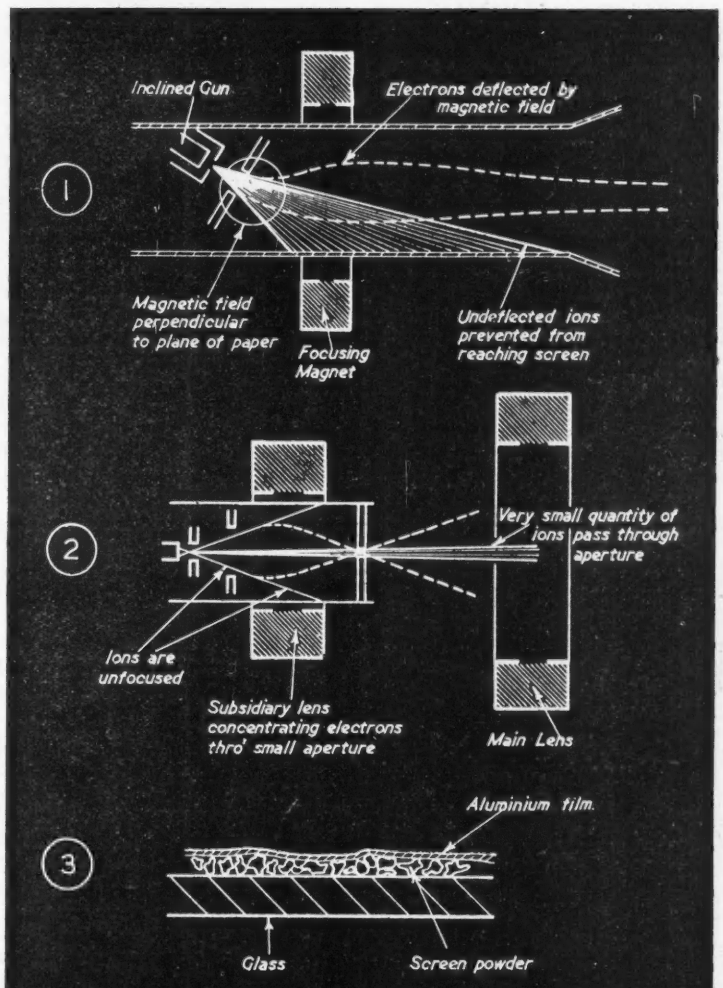
The ratio of charge to mass of the ions is, of course, very much smaller than the e/m of the electron. Since the trajectory of a charged particle in an electrostatic field is independent of e/m, it follows that a negative ion emitted from the cathode will be focused and deflected along the same path as an electron. In a magnetic field, the trajectory depends on the momentum of the particle. Since the momentum of an oxygen ion is about 160 times that of an electron of the same energy, it follows that magnetic fields of strength sufficient to focus and deflect electrons will have hardly any effect on the path of negative ions. Thus, in a tube with magnetic deflection and focusing, the ions will reach the fluorescent screen as a divergent beam, for all practical purposes unfocused and undeflected, while the focused electron beam is tracing out a normal raster. The effect of the ions on the fluorescent screen is to produce a thin film of deactivated material on the surface exposed to the ion bombardment. At low accelerator voltages a high proportion of the electron energy is absorbed by this film, and the raster will have a dark patch in the centre, which can be of sufficient intensity to cause trouble if the tube is in a television receiver.

The elimination of this undesirable effect may be tackled in several ways. The most effective method would be the use of a screen material resistant to the ion poisoning, if this could be achieved without sacrificing brightness and whiteness. So far, however, the most efficient powders with the required colours seem to be of the zinc sulphide family, and this group of powders has high sensitivity to ion burn.

The second line of approach would seem to be the elimination of ions from the tube. This is obviously impossible in the case of the continuously evacuated oscillograph, but there is a suggestion from the work of Bachman and Carnahan[1] that long processing of high-vacuum tubes on the pump before seal-off may minimise the production of negative ions.

The third line of approach, and one which seems most likely to succeed at the present time, is the use of some form of ion trap, which intercepts the ions but allows electrons to pass freely.

The difference in behaviour of ions and electrons in magnetic fields gives rise to two types of trap. In one type, the electron (and ion) beam is produced by a gun which is inclined to the main axis of the tube (Fig. 1). The electron beam is then deflected by means of a magnetic field so as to pass



*Research Labs., G.E.C., Wembley.

through an aperture and thence along the main tube axis, to be focused and deflected, while the ions are blocked off. A variant of this type employs an axial beam-producing gun, and separates the ions from the electrons by crossed electrostatic and magnetic fields. The former field, produced by a pair of plates deflects both ions and electrons, while the latter brings the electrons back onto the tube axis.

The disadvantage of this type of trap is that, if unreasonably long tubes are to be avoided, the aberrations introduced by the magnetic deflection are quite severe. Examples of this type are described in British Patent Specification No. 458,270 (Whelpton); U.S. Patent Specification No. 2,274,586 (Branson); and page 343, *Principles of Television Engineering* (Fink).

A second type of trap, illustrated in British Patent Specification No. 480,948 (Nicoll) employs a magnetic focusing field to concentrate the electrons through a small aperture, through which only a small part of the diverging ion beam will pass. (Fig. 2.) Again, abberations are introduced by the necessity for employing a short focus lens, if tube length is to be kept down.

A fundamentally different form of trap, depends for its action on the fact that the depth of penetration for complete absorption in matter of a singly charged paricle of mass M is

$$p = \frac{KV^2e^2}{M}$$ where K depends on the material, and (Ve) is the energy of the particle in electron volts.[4] Thus an electron will penetrate a thickness of material approx. 30,000 times that which will absorb an oxygen ion of the same energy. The ions may thus be filtered through a thin film of material such as a layer of aluminium evaporated onto the screen, or an overbinder such as potassium silicate.[5, 6, 7] (Fig. 3).

The aluminium layer has decided advantages other than its use as an ion filter, such as the provision of a conducting coating, and the back reflectively which enhances the tube contrast and light output. Since the thickness of aluminium which it is possible to evaporate consistently onto a screen is of the order of 500-1,000 A°, some electron energy will be lost (about $2eKv$), but above 6 kV, this is compensated by the reflectivity and the fact that the screen does not suffer from voltage saturation. This thickness of material is sufficient to absorb oxygen ions of energy up to 300eKv. This method is the most useful solution to the problem so far suggested.

REFERENCES

[1] Bachman and Carnahan, *Proc. I.R.E.*, 26, pp. 529-539, May, 1938.
[2] Liebmann, *Nature*, 157, Feb. 23, 1946. (Letter.)
[3] Broadway and Pearce, *Proc. Phys. Soc.*, 51, 2, pp. 335-348, March, 1939.
[4] Bethe, *Ann. der Phys.*, 5, 1930, pp. 374.
[5] Bachman, *G.E. Review*, 48, 9, pp. 13-19, Sept., 1945.
[6] Epstein and Pensak, *R.C.A. Review*, VII, 1, pp. 5-10, March, 1946.
[7] British Patent Specification No. 402,411.

Mass and Energy—*A Misconception corrected*

IT is evident, from many recent writings on the atomic bomb, that a serious misconception still persists, not only in the popular press but also in the minds of some scientists. The idea that matter and energy are interconvertible is due to a misunderstanding of Einstein's equation, $E = mc^2$. This equation does not state that a mass, m, can be converted into an energy, E, but that an object of mass m contains simultaneously an energy, E.

In nuclear reactions there is never any actual change in the total mass content of the universe. For example, the fission of a nucleus of mass M into two equal fragments, each of rest mass m_o, sets free an energy of

$$E = (M - 2m_o)c^2 \quad \ldots\ldots\ldots\ldots (1)$$

which gives a velocity, v, to each fission fragment. The kinetic energy of each fragment at this velocity is given by the Lorentz equations as

$$\tfrac{1}{2}E = m_oc^2\left(\frac{1}{\sqrt{1 - v^2/c^2}} - 1\right). \quad \ldots (2)$$

Now the mass of a particle at velocity v *is*

$$m = \frac{m_o}{\sqrt{1 - v^2/c^2}} \quad \ldots\ldots\ldots\ldots (3)$$

Therefore, Equation (2) becomes

$$\tfrac{1}{2}E = mc^2 - m_oc^2. \quad \ldots\ldots\ldots\ldots (4)$$

Combining Equations (1) and (4) gives:

$$(M - 2m_o)c^2 = 2mc^2 - 2m_oc^2, \quad (5)$$

from which, by cancellation of terms,

$$M = 2m. \quad \ldots\ldots\ldots\ldots (6)$$

The final total mass is thus exactly equal to the initial mass. The system does not lose any mass until collisions with other particles gradually remove kinetic energy and mass from the fission fragments, and then the mass gained by the other particles is exactly equal to the mass lost by the fission fragments. Mass is not destroyed but merely dispersed, just as the potential energy originally contained in the fissionable nucleus is dispersed as kinetic energy of the particles struck by the fission fragments.

In the preceding derivation, M is the mass of the fissionable nucleus plus the neutron added to trigger it off. Also, it was assumed that M is essentially at rest, that two exactly equal fission fragments are produced, and that no extra neutrons are released. If it is assumed that both the fissionable nucleus and its triggering neutron are originally in motion, that unequal fission fragments are produced, and that several neutrons are liberated at high velocities, the equations are more involved, but the same result is obtained, namely, that the sum of all masses before the reaction is exactly equal to the sum of all masses after the reaction. In calculating the kinetic energy released or consumed by nuclear reactions from the formula, $E = (\Delta m)c^2$, the rest masses and not the actual masses must be used in computing Δm.

Likewise, in the "annihilation" of a position and electron, it can be shown (remembering that the mass of a photon is $h\gamma/c^2$) that the total mass of the photon or photons produced is exactly equal to the combined mass of the electron and positron "annihilated."

The law of conservation of mass still holds.

C. ROLAND EDDY,
Philadelphia 19, Pennsylvania.
—From "*Science*," Sept., 1946.

Cylindrical Draughting Machines for Electrical Diagrams, etc.

By A. M. HAWORTH, A.M.I.E.E.

THIS note describes a drawing office appliance of interest to readers concerned with the preparation of electrical connexion diagrams and similar drawings. It has been produced by the company for use in their own drawing offices and is now published as the idea may prove helpful to others. The company, however, has not developed this special drawing board on a commercial basis, but it is believed that Messrs. E. N. Mason & Sons, Ltd., Arclight Works, Colchester, Essex, are prepared to undertake supply.

In the drawing of electrical diagrams the lines are, in general, horizontal and vertical with circular or rectangular symbols. For the above conditions it is possible to draw the lines on the outer surface of a cylinder. The cylindrical draughting machine consists of a 15 in. diameter cylinder closed at the ends and mounted freely on a shaft and supported in end brackets as shown on the photograph. A straightedge along the front of the cylinder is supported by V bearings in side brackets which can be raised or lowered to suit the draughtsman. Holes are drilled in the side brackets for this purpose. A backing sheet of stiff paper ruled with 1/10 in. square is placed on the surface of the cylinder and a sheet of semi-transparent drawing paper is placed over it. Both sheets are fixed to the cylinder by strips of scotch adhesive tape along the upper and lower edges. The lines showing through the drawing paper are guides for the setting out and spacing of the conductors and symbols.

The method of operation is as follows:

Horizontal lines are made by turning the cylinder to the desired position and drawing along the straightedge which is parallel to the axis. For vertical lines, the pencil point is put on the straightedge against the paper and the cylinder turned to suit the length of the line. For lines at 45° or 60° a small set-square, bent to the curvature of the cylinder, is used. Two slots at 60° are cut in the 45° set-square. A small vee is cut at the apex of the set-square. This is used when making vertical dotted lines when the set-square is placed on the shelf of the straightedge and the pencil point placed in the vee. As the cylinder is turned slowly the pencil can be pushed in and out to make the dotted line without any side movement. On the 1 in. diameter curvature circles up to 3 in. diameter may be drawn with compasses without visible distortion.

The advantages claimed for this type of drawing board are as follows:

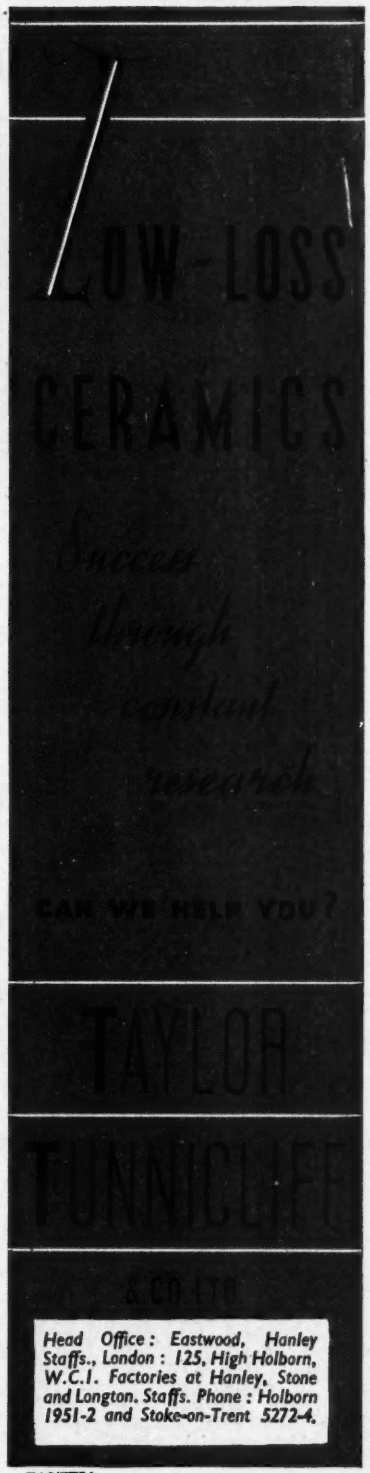
The straightedge is always parallel to the axis of the cylinder and it can be removed at any time by lifting it out of its vee bearings, if it is desired to see the whole diagram.

The working point of the cylinder is at a relatively constant distance from the eye and the illumination of the surface is also relatively uniform. Both these factors are desirous from the standpoint of the operator.

A small flat hand rest is placed on the shelf of the straightedge and provides a satisfactory rest for the hand when printing.

The first sample of the cylindrical draughting machine was made in October, 1944, and since then many diagrams have been made successfully.

The Metropolitan-Vickers Electrical Company, to whom we are indebted for permission to reproduce this note, wish to make it clear that they cannot entertain any inquiries on the subject.
—Ed.


LOW-LOSS
CERAMICS
Success through constant research
CAN WE HELP YOU?
TAYLOR
TUNNICLIFF
& CO LTD
Head Office: Eastwood, Hanley Staffs., London: 125, High Holborn, W.C.1. Factories at Hanley, Stone and Longton, Staffs. Phone: Holborn 1951-2 and Stoke-on-Trent 5272-4.
TAS/TT54

BOOK REVIEWS

Television Simplified

Milton S. Kiver, (D. Van Nostrand Co. Inc., New York, 1946. 375 pp. $4.75. In England 28s. 6d.)

This book sets out to explain American Television in a simple non-mathematical manner. Its scope and presentation are well suited to this purpose, and no doubt the book will be well received in America. The British reader will not find it so useful, however, because of the many differences between the American and British television standards, which make much of the book very misleading if applied directly to the British Television Service. The expert will be able to make adjustments for these differences, but the type of reader for whom the book is intended will not find it easy to do so.

The first chapter outlines the basic television system, and each succeeding chapter deals with a section of the receiver, until chapter 11 finds us analysing and aligning the complete set. There follows chapters on colour television, frequency modulation, and servicing. The book is plentifully supplied with illustrations, which are always adjacent to the relevant text. Many of these are included by courtesy of R.C.A., G.E., C.B.S., I.R.E., etc., and form the most useful part of the book, particularly Figs. 11.2 and 11.4, which give the circuit diagram, with component values, of a complete receiver covering five television bands, one broadcast band, and two short-wave bands. The diagrams, which were specially drawn for the book, however, have not all been properly vetted from the technical standpoint. Figs. 3.2, 5.14, 6.13, 9.3, 9.15, 9.18, 9.18A, 9.20B (compare 14.12), 10.2, all contain errors, some small, some serious, which will undoubtedly confuse the beginner.

Unfortunately, errors and obscurities are not confined to the diagrams. The account on page 90 of the operation of the audio rejector trap is quite wrong; it is, of course, a form of negative feedback. The frame-synch. integration in the circuit of Fig. 10.1 is not due to the grid-circuit time-constant, as stated, but to the 0.04 μF condenser, and 33,000 ohm resistance in the anode circuit. The same type of error is repeated in the description of Fig. 10, the essential components here being a 3-stage R.C. filter, not the grid-circuit time-constant as stated at the foot of page 236. Fig. 6.7 gives ratios and phase displacements between two voltages, E_L and E_g which, in Fig. 6.9 we find are across the same two points in the circuit. On page 332 we are advised, on grounds of safety, to avoid measuring the H.V. supply potential, but to connect a voltmeter across the series filtering resistor instead. Since *both* ends of this resistor are at a high potential, this method is, if anything, more dangerous, besides being very inaccurate when worked out by the method indicated. The connexion of a milliameter across the last (earthy) resistor of the bleeder chain had not, apparently, occurred to the author.

This sort of thing continues throughout the book, but limitations of space prevent detailed reference to it here. One is led to suspect that the author has had only the slightest practical experience of television, and actually does not himself understand the fine points of many of the circuits he describes. He has an undoubted flair for simple presentation, but would be well advised to have the book vetted by a competent designer, in order to re-write the offending portions. When this is done "Television Simplified" should find a well-deserved place in the literature, bridging as it does the gap between the highly technical, and the ultra-popular.

EMLYN JONES.

Electrician's Maintenance Manual

By W. E. Steward. 144 pp. 53 Figs. (George Newnes, Ltd.) 6s. net.

This small manual deals expressly with the maintenance and repair of motors and motor control equipment. The book in general is well laid out and is easy to read. The importance, to the young maintenance engineer of the I.E.E. and other regulations is well emphasised.

Some few items might be modified, such as : On page 29 the second paragraph refers to an A.C. starter and is liable to confuse a student; on page 49 no mention is made of any discharge resistance across the field and "20" on page 97 refers to 20° without mention of number of poles nor electrical or mechanical degrees. Finally, no mention is made concerning bimetal strips in starters.

On the whole, however, the book is to be highly recommended to the young installations engineer.

F. COLBURN.

Books reviewed in this Journal can be obtained from

H. K. LEWIS & Co. Ltd.

136 Gower Street, W.C.1

If not in stock, they will be obtained from the Publishers when available

Electron and Nuclear Counters

By S. A. Korff, New York ; Van Nostrand, 1946, xi + 212 pp. ($3.00 British price 18s. approx.)

During the last thirty or so years, the literature of charged particle counting by means of types of ionisation chambers has been growing. Particularly, since the advent of the radio valve allowed the use of more powerful and exact methods, has it diverged and spread over many scientific journals and the subject has become a classic example of that newly-named branch of science—radio-physics. It is, perhaps, not surprising then, that so few full-length texts have been written and that the art has only been embodied in what Dr. Korff calls, on the first page of his book, "a great number of quasi-empirical papers." In 1942, Lewis, of the Cavendish Laboratory, produced his "Electrical Counting," which covered well the "circuitry" of the subject, though referring little to actual counters. This new book sees to this and devotes six chapters to counters—their theory, construction and use—and only one to circuits. Lewis may be said to supply the radio, and Korff the physics of the subject.

The book opens with a clear discussion of the mechanism of the discharge counter, distinguishing clearly between the three regimes of operation, as an ionisation chamber, as a proportional counter and as a Geiger counter. This clears the ground for separate and more detailed chapters on each of the three—most space being allocated to the Geiger counter—and on constructional matters. Special purpose instruments are described, such as one to count neutrons in the presence of a strong background of gamma radiation. The section on construction is especially worthy of note and the practical details will prevent many failures in making counters.

It is good to note the stress placed by the author on the need for cleanliness if consistent results and long working instruments are required. Even when a counter has been successfully constructed and is in use, there are many precautions to observe if an accurate count is to be taken, and these are well covered in the next chapter on errors and corrections. The last chapter deals with the circuit technique of the subject, and describes amplifiers, scaling circuits, power supplies, et. A bibliography of some two hundred references completes the volume.

Produced in the clear, crisp style which we have grown to associate with American textbooks, this book is excellently printed on good paper and is very readable in all senses of the word. Although essentially of a practical nature, it does not, nevertheless, gloss over fundamentals and a balanced presentation is preserved. It will be found very useful by all, engineers and physicists alike, who have to deal with discharge counters—and their numbers are growing—and it should be a handy reference book on many a laboratory shelf.

E. D. HART.

MYCALEX
THE INSULATOR
REG'D TRADE MARK

May solve your INSULATION PROBLEMS

with the following UNIQUE COMBINATION OF PROPERTIES { HIGH DIELECTRIC STRENGTH ● NON-ABSORBTIVE LOW-LOSS FACTOR ● METAL INSERTS IF REQUIRED ● HEAT RESISTING ● MANUFACTURED TO CLOSE TOLERANCES ● NON-TRACKING ● RESISTANT TO FUNGUS GROWTH ● WILL NOT SHRINK OR WARP ● LOW EXPANSION CO-EFFICIENT

MACHINED OR MOULDED TO CUSTOMER'S REQUIREMENTS OR AVAILABLE IN SHEETS AND RODS.

Also makers of INGRAM-MYCALEX Capacitors utilising MYCALEX as a dielectric with plates moulded in, to form a sealed unit.

Phone CIRENCESTER 400 or SEND ENQUIRIES TO

MYCALEX COMPANY LIMITED

ASHCROFT ROAD, CIRENCESTER, GLOS.

MY 15

. . . another famous production from *The House of*

VOICE FREQUENCY FADERS, LOW FREQUENCY AND HIGH FREQUENCY ATTENUATORS

We shall be happy to supply the fullest information.

PAINTON & Company Limited NORTHAMPTON

In a world whose tempo is governed by the radio wave, it is necessary to think quickly and to think ahead. Marconi engineers have an advantage in this—the advantage of a technical background that takes in the whole history of wireless communications.

In the reconstitution of old services and the development of new ones, that experience will be vital. On land, on sea and in the air, in the future as in the past, communications will be linked with Marconi—the greatest name in wireless.

MARCONI

the greatest name in wireless

MARCONI'S WIRELESS TELEGRAPH COMPANY LTD
THE MARCONI INTERNATIONAL MARINE COMMUNICATION COMPANY LTD
MARCONI HOUSE, CHELMSFORD, ESSEX

Operation Protection

De La Rue Insulating Sleevings protect electrically, mechanically and methodically. Produced in diameters from 0·5 mm., in four types to British Admiralty and Air Ministry specifications—Varnished Cotton, Varnished Rayon and Rolled Silk. Wide range of single colours, stripes and multiple colours takes care of the most elaborate coding.

DELAFLEX
INSULATING SLEEVINGS

De La Rue Insulation Limited

IMPERIAL HOUSE · REGENT STREET · LONDON W.1 · ENGLAND
Tel.: REGent 2901. Cables: Delinsul, Piccy, London

D.A.10A (46)

CORRESPONDENCE

D.C. Amplifiers

SIR,—I was very interested to read the article by R. A. Lampitt on D.C. amplifiers in ELECTRONIC ENGINEERING for November, particularly since I have had a similar project under consideration for some time, although I have not yet had an opportunity to put it properly into practice.

Two further references to the subject are: "Survey of D.C. Amplifiers," by M. Artzt, *Electronics*, August, 1945, pp. 112-118, and "D.C. Amplification with a High Frequency Push-Pull Circuit," by F. Kerkhof, *Zeit. f. Techn. Phys.*, 1942, pp. 267-269.* "Amplifier for Thermo-electric Voltages," by E. Hendrick, *Elektrotechnische Zeit.*, February, 1941, pp. 193-196, is also of interest. Artzt mentions rather briefly the possibility of modulation systems, but Kerkhof gives in detail a circuit that is based on this principle.

It would seem that there are certain advantages in using a carrier of higher frequency. As well as its allowing a fundamentally higher signal frequency, it simplifies the elimination of carrier from the output, while a tuned amplifier, which is less cumbersome for the radio frequencies, reduces any trouble from harmonics. Harmonics can also be rejected by employing a different system of balancing, namely, feeding identical *in-phase* signals to the two modulator valves, and putting their outputs into a push-pull transformer. Such a transformer can be more easily constructed symmetrically when having the fewer turns that would be associated with a carrier of higher frequency. This arrangement would also obviate the necessity for an additional phase-splitting valve.

Turning to the details of Mr. Lampitt's circuit, I am a little uncertain about the effect of the cathode by-pass condensers for V_2 and V_3. I would have thought that below the frequency where their impedance became appreciable (and this must come within the range covered by the amplifier, since it extends to zero) a reduction in gain would have resulted from the negative feedback introduced by the cathode resistor. Possibly the condensers in question are small enough only to be effective at the carrier frequency. A reduction in gain might also be expected from the voltage-dropping resistor connected to the screen-grids of V_2 and V_3; this could be prevented by tying them directly to a fixed voltage.

Obviously, the amplifier described has served its purpose satisfactorily, and none of my remarks are intended to detract from the achievement of actually producing a workable instrument of such a type. However, in any future developments, it might be worth while to equalise exactly the gain of the two stages V_2 and V_3, perhaps by adjustment of cathode resistors. The amplifier could then be used, if wanted, with a push-pull input having a high degree of rejection to in-phase signals. One further possibility that might be considered is the introduction of an over-all negative feed-back by connecting a high resistance between the output terminal and the cathode of either V_2 or V_3, according to which way the initial unbalance had been introduced. A closer consideration of phase shifts might be necessary before the feasibility of this could be established, but it might prove possible to stabilise the overall amplification very closely by such means.—Yours faithfully,

B. E. NOLTINGK.

Mr. Lampitt replies:

"The cathode by-pass condensers for V_2 and V_3 are, as the above correspondent suggests, unnecessary from the point of view of the signal voltage E_s, since at a frequency approaching zero their reactance would be so high as to render them ineffective. It must, however, be remembered that these two valves are operating as carrier amplifiers, and at the carrier frequency the bias by-pass condensers are then effective in reducing negative feedback. The capacities are small enough to render the condensers ineffective at the highest A.C. voltage component of the signal, so that over the required signal frequency range the amplifier remains linear.

Negative feedback at the signal frequencies is inevitable, but in the apparatus in question the overall gain obtained was sufficient for the purpose in hand, so that further steps of increasing it were unnecessary. I do agree, however, that certain modifications to the circuit around V_2 and V_3 in Fig. 6 could be made to improve its efficiency as a modulator. The bias for V_3 could be obtained from an H.T. voltage divider in the same way as for V_2, and in addition the screens could be fed in a similar manner. Negative feedback would then be reduced to a minimum.

The individual stage gains of V_2 and V_3 are essentially equal, since the valves themselves are similar, the tuned load is common to both and the screens are joined to a common dropping resistor. The bias of V_3 is fixed at a value which enables that valve to operate under the required conditions, and in the process of balancing, the bias of V_2 is adjusted so that when the modulator is actually balanced, the anode current through each valve is the same. Thus, under these conditions of balance the gains are equal and the two valves are working on a similar part of their characteristics.

As the correspondent suggests, to apply a balanced signal input to the amplifier would be an advantage, and from the above it will be seen that the conditions are entirely suitable.

The application of overall negative signal feedback seems to present no real difficulty, and it may prove under certain conditions to be an advantage to use variable feedback as a gain control. However, many refinements have since been added to other apparatus of this type, and I have no doubt that if carried to its final conclusion the system could be made very versatile."

R. A. LAMPITT.

* I am indebted to Mr. H. M. Ross of Kodak Research Laboratories for mention of this paper. Mr. Ross has also built an amplifier working on the carrier principle.

We realise that in these difficult days it is not always easy for readers to obtain copies of this Journal. We make every endeavour to arrange an efficient service through the usual trade channels, but under present conditions, this is not always possible in outlying districts.

Readers could help by reporting all cases of difficulty to the Publishers.

In the event of persistent difficulty, a subscription can be taken out at this office, the rates being :—

Twelve months	£1	6	0	*post free*
Six	„	13	0	„ „
Three	„	6	6	„ „

and a copy will be posted on the day of publication.

Orders with remittance should be addressed to *Electronic Engineering*, Hulton Press, 43-44, Shoe Lane, London, E.C.4.

NOTES FROM THE INDUSTRY

Uniformity in Standards of Measurement

It was suggested at the recent Scientific Conference that greater uniformity in standards of measurement should be achieved, and further that the reformed units should be precisely related to the corresponding metric units. Tentative values for conversion factors were recommended as follows:

1 yard = 0.9144 metre exactly
or 1 inch = 25.4 mm.
1 lb = 0.453 592 37 kg.
or 0.453 592 3

The Conference advocated the adoption of the metric system in all fields of science.

Scientific Films

The first printed catalogue of Films of General Scientific Interest was recently published by ASLIB for the Scientific Film Association. The catalogue contains appraisals based on a definite system of grading as well as full details of content and availability. Information relating to the work and aims of the Scientific Film Association are given and copies are available from the Association, 34 Soho Square, London, W.1, price 5s. 3d. or direct from ASLIB.

Quality Through Statistics

The publication of a second edition of the handbook, "Quality Through Statistics," by A. S. Wharton, F.S.S., A.I.I.A., is announced by Philips Lamps, Ltd.

The purpose of the handbook is to put forward an elementary explanation of quality control methods as applied in Philips factories in a form that can be understood by those with little or no statistical knowledge. Mathematical formulæ are avoided wherever possible. The handbook may be had on application to Philips Lamps, Ltd., Publications Department, Century House, Shaftesbury Avenue, London, W.C.2, or through leading booksellers, price 6s. post free.

Marconi Instruments, Ltd.

A Southern area office and London showroom for this company has been established at 109 Eaton Square, S.W.1 Telephone: Sloane 8615. The representative in charge is Mr. R. J. Bailey.

Mullard Valve and Service Guide

Supplies of the Mullard Valve and Service Guide are now available to members of the trade The guide is divided into four sections; the first gives illustrations, in diagrammatic form, of the bases of the valves listed and their connexions, the range of valves dealt with being "E" series, battery types 1.4-volt and 2-volt, A.C. mains 4-volt, A.C./D.C. mains types, rectifiers, American types, UX base and special types. The second section gives characteristics and operating data, the third section equivalent tables and the fourth is devoted to a table of replacement and substituting types.

A complete range of valves suitable for modern low power transmitters is described in a publication "Mullard Valves for Amateur Communications," now available from Publications Department, The Mullard Wireless Service Co., Ltd., Century House, Shaftesbury Avenue, London, W.C.2.

Multicore Solders, Ltd.

A development in the packaging of cored solder wire is the production of the new Size One carton of Ersin Multicore Solder. This pack has been designed for service engineers and firms undertaking maintenance, and possesses considerable advantages over the nominal 1 lb. reels previously supplied. Multicore Solders, Ltd., stress the fact that these Size One cartons are not sold as containing 1 lb. each of solder: they contain a specified length which will enable sale prices to be maintained equivalent to the nominal 1 lb. reels. Retail selling prices are as follows:

60/40 alloy 14 S.W.G. containing 56 ft. ..... 6s. 0d. each
60/40 alloy 18 S.W.G. containing 151 ft. ..... 6s. 9d. each
40/60 alloy 13 S.W.G. containing 36 ft. ..... 4s. 10d. each
40/60 alloy 16 S.W.G. containing 83 ft. ..... 5s. 3d. each

A New Radiogramophone

Details have been released of the "Ether Conqueror," a new radiogramophone manufactured by Dynatron Radio, Ltd., Perfecta Works, Ray Lea Road, Maidenhead, Berks. The instrument utilises the new record charger with H.F. needle armature pick-up, with a sapphire point.

The British Sound Recording Association

Membership of the B.S.R.A., formed in 1936 by a group of electro-acoustic engineers and amateur technicians, is open to all persons interested in, or connected with, sound recording and is divided into two classes: Full member, who must be over 21 years of age, annual subscription £1 1s. 0d.; associate member, for those persons under 21 years of age, annual subscription 10s. 6d. The president of the Association is Mr. L. E. C. Hughes, Ph.D., B.Sc., hon. general secretary, Mr. R. W. Lowden, and hon. technical secretary and editor, Mr. D. W. Aldous. Communications should be addressed to: The British Sound Recording Association, BCM/BSRA, London, W.C.1.

Portable P. A. Equipment

R.S. Amplifiers, Ltd., have recently redesigned the whole of their sound amplification products and now have in production a complete portable P.A. equipment comprising an amplifier, ribbon-type microphone and loudspeakers to match. The amplifier is made in two types: the A.12 for A.C. operation only on 220-250 volts with a power consumption of 80 watts, and the U.12 for universal operation on A.C. or D.C. 200-250 volts with a power consumption of 100 watts. Both have a power output of 12 watts with a peak of 15 watts The ribbon-type microphone has an output impedance of 15 ohms with an output level of – 90 db. below one volt-bar, while the twin loudspeakers incorporate alloy magnets and provide a high degree of sensitivity with an impedance of 15 ohms at 400 cycles. These loudspeakers lock back to back and accommodate the amplifier, microphone and all the necessary cables.

American Agent for British Electrical Industry

Mr. Richards W. Cotton, 347 Madison Avenue, New York, offers his services in representing in the U.S.A. any British manufacturers in the electronic, electrical or electro-mechanical fields. Mr. Cotton will also make manufacturing arrangements for British manufacturers with American firms for the production in Britain for the home and export market.

Eddystone Short Wave Manual

Messrs. Stratton & Co., of West Heath, Birmingham, have issued No. 5 of their series of Short Wave Manuals describing the following equipment: 60 Mc/s 15 W transmitter, 5-10 m. 3-valve converter, 28 Mc/s C.W. and telephony transmitter, V.H. frequency meter, and other items.

Full constructional details are given in each case, and all the equipment has been tested and found satisfactory.

Copies of the manual can be obtained from Messrs. Webbs Radio, Soho Street, London, W.1, price 2s. 6d. plus postage.

Addressing The Public

A second edition of the handbook, "Addressing the Public," by P. J. Walker, has been issued by the Acoustical Manufacturing Co., Ltd. The booklet deals with the fundamentals of good public address equipment and among the points discussed are the Location of Equipment (both indoor and outdoor), Loudspeaker Matching, Microphone Lines, Gramophone Pickup Matching, Testing and Operating. A useful Appendix gives a series of diagrams of suggested methods for connecting 15-ohm loudspeakers, showing the percentage of total output wattage developed in each speaker. Copies of the booklet can be obtained from the Acoustical Manufacturing Co., Ltd., Huntingdon, price 3s. 6d. post free.

Radio Receiver Specifications

"Radio Receiver Specifications, 1945-46" is the title of a booklet containing condensed technical specifications of radio receivers released since the war and marketed by leading manufacturers. Brief descriptions are given of sets, model numbers, styles of cabinets, valves employed, intermediate frequencies, wavebands covered, power outputs, power supplies, and the retail prices of 138 sets by 55 makers. Details are correct up to October 29, 1946. The booklet, compiled by *The Wireless and Electrical Trader*, is published by The Trader Publishing Co., Ltd., Dorset House, Stamford Street, London, S.E.1, price 9d. net.

Good-bye, Mr. Richards

Mr. K. Richards, formerly in the Cossor instrument department, is going to Johannesburg to take up a position as manager of the Scientific Instruments Division of Bartle & Co., who are agents for Cossor cathode-ray tubes and electronic instruments.

Multi-contact Connectors

Films and Equipments, Ltd., 138 Wardour Street, London, W.1, have issued an excellently-produced catalogue of their electrical contacts for communication and allied equipment. The multi-contact plugs and sockets are for electronic low-level circuits and are especially suitable where limited space and speed of coupling are of paramount consideration. The information given is very comprehensive and blank pages are provided at the end of each range of connectors for notes and additions. The price of the catalogue is 5s. net.

A. C. Wickman, Ltd., and Diaplastics, Ltd.

A. C. Wickman, Ltd., Tile Hill, Coventry, announce that following their appointment as sole world agents for Diaplastics Ltd., designers and manufacturers of electronic equipment, a new division of their organisation (Electronics Division) is being established with Mr. F. L. Gladwin (late of Diaplastics, Ltd.) as specialist-in-charge. The products already developed consist of complete H.F. equipment for plastic welding and dielectric and induction heating.

Wayne-Kerr Laboratories, Ltd.

Component Bridge

Wayne-Kerr Laboratories, Ltd., Sycamore Grove, New Malden, Surrey, announce that the price of their type B.101 component bridge is now 26 gns.

C. Gertler Transfers

C. Gertler, 29/31 Cowcross Street London, W.C.1, repairers of electrical and scientific instruments, announce that the business has been transferred to W. O. Prescott, Ltd.

Glasgow Technical Exhibition

The first post-war Scottish Exhibition of engineering and technical products was held at the Kelvin Hall, Glasgow, from November 15-23.

Among the firms exhibiting were: Ardente Acoustical Laboratories, Ltd., British Vacuum Cleaner & Engineering Co., Hoover, Ltd., Land Speight & Co., Ltd. (Glasgow), Marconi Instruments, Ltd., Morgan Crucible Co., Ltd., A. Reyrolle & Co., Ltd., Scophony, Ltd., Sunvic Controls, Ltd., and *Electronic Engineering* was pleased to have the first opportunity of welcoming Scottish readers and inquirers at its stand.

A report on some of the exhibits will appear in next month's issue.

MELTON METALLURGICAL LABORATORIES LTD.

Liquid Silver

Platinum & Gold Solutions

For Metallising Mica Ceramic Quartz etc.

Low Melting Point Solder and Non-Corrosive Liquid Flux (A.I.D. Approved)

IPSWICH ROAD TRADING ESTATE SLOUGH, BUCKS.

'Phone: Slough 20992

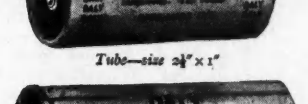
Agents for Australia:
A. S. HARRISON & CO. PTY. LTD.
85 CLARENCE STREET, SYDNEY

DALY

ELECTROLYTICS

Tube—size 2½" × 1"

Can—size 4½" × 1¾"



Bloch—size 4⅝" × 1½"

The DALY range covers all requirements

Note—All Condensers bear the date made

DALY (CONDENSERS) LTD

Condenser Specialists for over 20 years

West Lodge Works, The Green, Ealing, W5

'Phone—Ealing 4841

ABSTRACTS OF ELECTRONIC LITERATURE

INDUSTRY

Electronic Comparator Gauge
(W. H. Hayman)

A standard-size piece of work is used to balance an indicating meter to centre. Desired limits of deviation are then set up. Movement of the gauge point in production inspection varies the inductive relationship between two coils to light lamps indicating standard oversize and undersize.

—*Electronics*, July, 1946, p. 135.

Simplified Thyratron Motor Control
(H. H. Leigh)

A method of thyratron grid control is discussed which, combined with a regulating mechanism, provides a simple means of motor control. Typical applications suggested include: (a) tachometer testing equipment; (b) control of the drive to an automatic printing machine; and (c) fine-wire reeling equipment control. Design and operation of the grid control circuit is considered in detail. Complete circuits of systems for speed and acceleration control are presented and an indication given of precautions to be observed in their practical application.

—*Gen Elect. Rev.*, September, 1946, p. 18.*

The Eniac, an Electronic Computing Machine
(D. R. Hartree)

The Eniac (Electronic Numerical Integrator and Computor) is a general-purpose calculating machine, operating by the counting of electrical pulses by electronic counting circuits. It consists of a number of separate units for carrying out the operations required in an extended computing problem, such as addition, multiplication and construction of each unit is given. High-speed computation is of the operation and construction of each unit is given. High-speed computation is possible, the time taken for the multiplication of two 10-figure numbers being 3 milliseconds.

—*Nature*, October 12, 1946, p. 500.*

Problems in the Design of High-Frequency Heating Equipment
(W. M. Roberds)

Although some of the first high-frequency power generators which were used for industrial-heating purposes were merely converted radio transmitters, it was found, as the art progressed, that the problems involved were quite peculiar to the industrial class of service. Probably the greatest problem facing the designer of industrial radio-frequency generators is that of the coupling circuit through which the generated power is fed into the load.

Various coupling schemes are discussed and the advantages and disadvantages of each are pointed out. A simple analysis of a transformer-coupled circuit is made by showing how the inherent Q of the load is reflected into the tank circuit.

It is suggested that a generator can be made more versatile if low-impedance tank circuits are employed.

—*Proc. I.R.E.*, July, 1946, p. 489.

ELECTRO-MEDICAL

A Piezo-Electric Unit for General Physiological Recording
(J. L. Malcolm)

An apparatus is described in which use is made of the piezo-electric properties of an X or A.T.-cut quartz crystal, by means of which a wide range of physiological phenomena may be recorded with the use of amplifier-cathode ray tube technique. The unit contains its own pre-amplifier, is simple to construct and robust, and considerably widens the scope of the usual electrical recording apparatus.

—*Jour. Sci. Inst.*, July, 1946, p. 146.

Double-Beam C.R. Tube in Biological Research
(T. H. Bullock)

New cathode-ray tube offers many advantages for simultaneous observation and recording of two or more fast transient phenomena such as nerve potentials. Simple method of modifying a Du Mont type 247 oscilloscope to use the type 5SP double-beam tube is given.

—*Electronics*, July, 1946, p. 103.

Annales de Radioelectricite

This is the title of a new publication issued by the French Radio Association (Cies. Francaises Associees de T.S.F.) of 79, Boulevard Haussmann, Paris. Copies are not at present for sale commercially, and the contents comprise reports of the work done in the Asociations's research centres. Among these reports are:

A contribution to the physics of velocity modulation tubes. (R. Warnecke).

The screening effect of a cylindrical tube in a magnetic field. (J. Laplume).

General information on the Associated French Radio Companies and their work during the occupation. (Vol. 1 No. 1).

The diffraction and reflexion of guided waves. (E. Girardeau).

A new method of integration for second order differential equations. (F. Rabinovitch).

The problem of mine location—Detection of small masses of metal. (H. Grumel & P. Morel).

Abstracts of future articles will be given as often as space permits.

TELEVISION

A Method of Measuring the Degree of Modulation of a Television Signal
(T. J. Buzalski)

A method of measuring the degree of modulation on a standard television signal is described. The double sideband output of which contains direct current component in addition to the visual signal. Means are provided to interrupt this composite signal periodically by short-circuiting the diode output load impedance for a brief interval, thus establishing a reference zero signal. The resultant modified signal, including the zero reference level, may be observed by means of a cathode-ray oscilloscope capable of handling only alternating current signals. The trace on the face of the oscilloscope will contain all of the information required to measure the degree of modulation attained.

—*R.C.A. Review*, June, 1946, p. 265.

The Image Orthicon—A Sensitive Television Pickup Tube
(A. Rose, P. K. Weimer and H. B. Law)

The image orthicon is a television pick-up tube incorporating the principles of low-velocity-electron-beam scanning, electron image multiplication, and signal multiplication. It closely approaches the theoretical limit of pickup tube sensitivity and is actually 100 to 1,000 times as sensitive as the ionoscope (1850) or orthicon (1840). It can transmit pictures with a limiting resolution of over 500 lines and, if properly processed, is relatively free from spurious signals. At low lights, the signal output increases linearly with light input: at high lights, the signal output is substantially independent of light input. The tube is completely stable at all light levels. The signal output is sufficiently high to make the operation of the tube insensitive to many of the preamplifier characteristics that are normally considered significant. The construction, operation, electron optics, and performance of the tube are discussed.

—*Proc. I.R.E.*, July, 1946, p. 424.

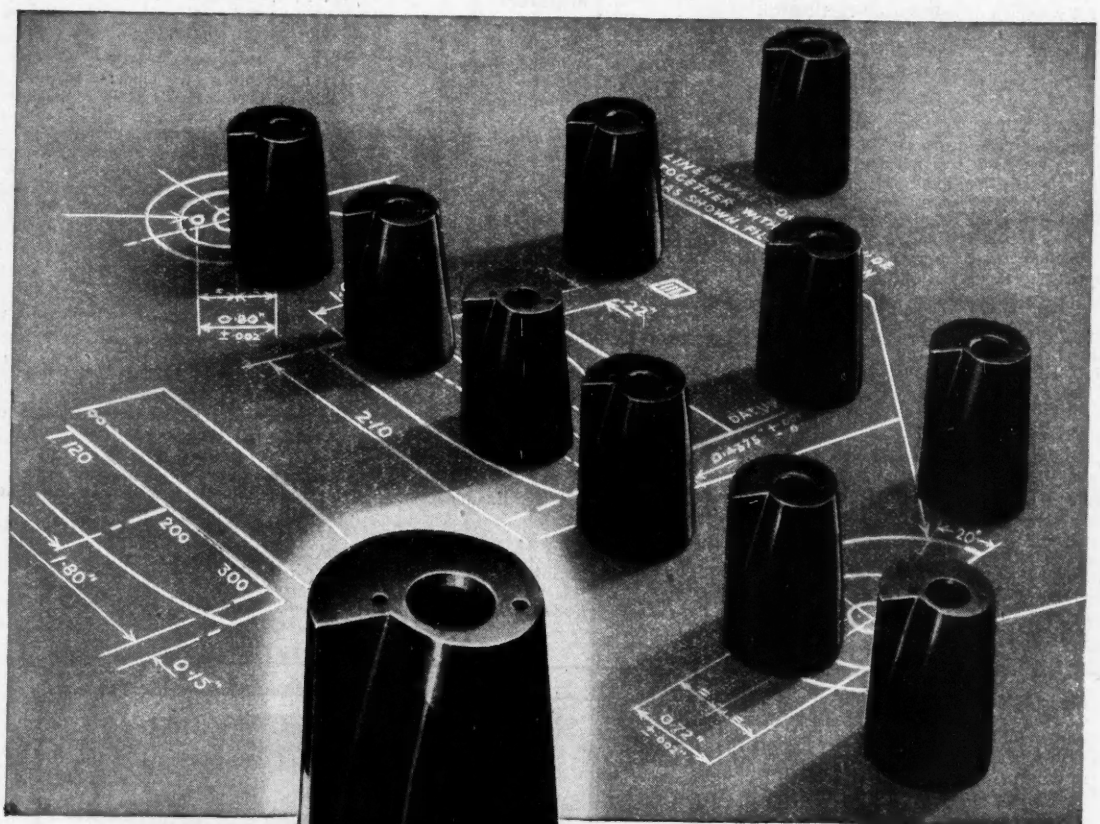
An Experimental Colour Television System
(R. D. Kell, G. L. Fredendall, A. C. Schroeder, and R. C. Webb)

A description is given of colour television apparatus using an image orthicon in the colour camera for direct pickup of studio scenes. A sequential three-colour semi-mechanical system is used. The associated sound channel is transmitted on the edge of the picture during a portion of the horizontal blanking period.

—*R.C.A. Review*, June, 1946, p. 141.

* Abstracts supplied by the courtesy of Metropolitan Vickers Electrical Co. Ltd. Trafford Park, Manchester

THIS WAS THE PROBLEM — *To reduce production time on a vital component of a Bombsight Computor.*



Trail Cams moulded by a transfer process by Electro-Plastics Ltd., Watford, Herts

— solved by moulding in BAKELITE LIMITED

The component was a Trail cam for a Bombsight Computor, originally machined from the solid and formed on a specially designed machine. By moulding the cam in Bakelite Material X. 5073 a total saving of over 30 minutes per cam was effected, some operations, including the special machining, being either simplified or eliminated.

TREFOIL

BAKELITE PLASTICS

REGD. TRADE MARKS

Pioneers in the Plastics World

T66

BAKELITE LIMITED · 18 GROSVENOR GARDENS · LONDON · S.W.1 · Telephone : SLOANE 9911.

DECEMBER MEETINGS

Institution of Electrical Engineers

All meetings of the London Section will be held at The Institution of Electrical Engineers, Savoy, Place, Victoria Embankment, London, W.C.2.

Radio Section

Date: December 4. Time: 5.30 p.m.
Lecture: "The Elements of Wave Propagation Using the Impedance Concept."
By: H. G. Booker, Ph.D.
Date: December 10. Time: 5.30 p.m.
Discussion on "The Design and Performance of Receiving Aerials for Television."
Opened by E. C. Cork, B.Sc.

Measurements Section

Date: December 13. Time: 5.30 p.m.
Lecture: "A Millisecond Chronoscope."
By: R. S. J. Spilsbury, B.Sc. (Eng.) and A. Felton, B.Sc. (Eng.).
Secretary, I.E.E., Savoy Place, London, W.C.2.

Cambridge and District Group

Date: December 17. Time: 6 p.m.
Held at: The Cambridgeshire Technical College.
Lecture: "Recent Advances in Electronics Applied to Medicine."
By: G. Parr, A.M.I.E.E.
Group Secretary: D. H. Hughes, c/o Pye, Ltd., Radio Works, Cambridge.

The British Institution of Radio Engineers

Date: December 19. Time: 6 p.m.
Held at: The London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1.
Lecture: "Quartz Oscillators."
By: P. Vigoureux, D.Sc.
Secretary: G. D. Clifford, 9, Bedford Square, London, W.C.1.

The Institute of Physics

Electronics Group

Date: December 17. Time: 5.30 p.m.
Held at: Room 87, The Polytechnic, Regent Street, London, W.1.
Lecture: "Applications of Nuclear Physics in Medicine."
By: W. V. Mayneord, F.Inst.P.
Secretary: A. J. Maddock, "Sira," Southill Road, Elmstead Woods, Chislehurst, Kent.

Industrial Radiology Group

Date: December 6. Time: 6.30 p.m.
Held at: The Royal Society, Burlington House, London, W.1.
Lecture: "The X-ray Examination of Radio Valves."
By: E. G. W. Bowers.
Lecture: "Magnified Images."
By: C. Croxson, F.Inst.P.
Secretary: Dr. L. Mullins, Research Laboratory, Kodak Ltd., Harrow, Middlesex.

Scottish Branch

Date: December 10. Time: 6.30 p.m.
Held at: The University of Glasgow.
Lecture: "Betatrons."
By: Prof. Oliphant, F.Inst.P., F.R.S.
Secretary: W. G. Marskell, Messrs. Babcock & Wilcox, Ltd., Renfrew.

Manchester Branch

Date: December 12. Time: 6.30 p.m.
Held at: The Reynolds Hall, Manchester College of Technology.
Lecture: "Colour and the Eye."
By: Dr. J. H. Shaxby, F.Inst.P.
Note: This is a joint meeting of the Manchester and District Branch and the Illuminating Engineering Society.
Secretary: Dr. F. A. Vick, Physics Department, The University, Manchester, 13.

The Television Society

The scheduled meeting is postponed—see meeting December 10 for Radio Section of The Institution of Electrical Engineers.
Lecture Secretary: G. Parr, 68, Compton Road, London, N.21.

The Institution of Post Office Electrical Engineers

Informal Meeting

Date: December 9. Time: 5.0 p.m.
Held at: 9th Floor, Faraday Building (South Block), Knightrider Street.
Lecture: "The Circuit Laboratory in War-time."
By: C. H. White, A.M.I.E.E.
Secretary: W. H. Fox, Engineer-in-Chief's Office, (T.P. Branch), Alder House, London, E.C.1.

MARCONI INSTRUMENTS LTD
pioneer designers of
Communications Test Equipment
can now supply their

VALVE VOLTMETER
TYPE TF428B

FOR IMMEDIATE DELIVERY

The instrument measures both direct and alternating currents at audio and radio frequencies; its performance exemplifies Marconi proficiency in communications technique.

Full specification available on request.

MARCONI INSTRUMENTS LTD
ST. ALBANS, HERTS. Phone: ST. ALBANS 4323/6
Northern Office: 30 ALBION STREET, HULL. Phone: Hull 16144
Western Office: 10 PORTVIEW ROAD, AVONMOUTH. Phone: Avonmouth 438 Southern Office: 109 EATON SQUARE, LONDON, S.W.1. Phone: Sloane 8615

THE

COSSOR

HIGH VACUUM

DOUBLE BEAM OSCILLOGRAPH

giving

VISUAL TWO-DIMENSIONAL
delineation of any recurrent law.

•

RELATIVE TIMING OF EVENTS
and other comparative measurements
with extreme accuracy.

•

PHOTOGRAPHIC RECORDING
of transient phenomena

and

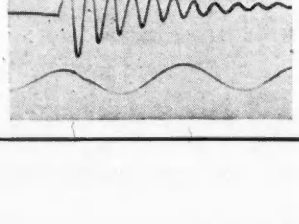
SIMULTANEOUS INDICATION
of two variables on a common time axis.

Completely embracing all the above functions, of which the last is unique, the Cossor Double Beam Oscillograph is inherently applicable to all problems arising in

RECORDING, INDICATING & MONITORING
when the effects examined can be made available as a voltage.

A. C. COSSOR LTD.,
INSTRUMENT DEPT.,
HIGHBURY, LONDON, N.5

Phone: CANonbury 1234 (30 lines)
Grams: Amplifiers, Phone, London



B T-H

ELECTRONIC EQUIPMENT

for

INDUSTRY

Applications include:—

RESISTANCE WELDING
HIGH FREQUENCY HEATING
POWER CONVERSION
TIMING, WEIGHING, COUNTING,
and control for
LIGHTING, VOLTAGE, SPEED,
REGISTER, AND TEMPERATURE
also
SERVO-POSITION CONTROL

•

BTH RUGBY
THE BRITISH THOMSON-HOUSTON COMPANY LIMITED, RUGBY, ENGLAND
A3638N

AEI

Tecnaphot
LIMITED
RUGBY

Scientific Glasswork to Customers' Requirements

Manometers,
Condensers,
Thermometers,
etc., etc.

PITMAN'S
Radio Books

THE SUPERHETERODYNE RECEIVER

By Alfred T. Witts, A.M.I.E.E.
An outstanding book by an experienced practical man, giving expert practical information on construction and maintenance. Now in its sixth edition, it should be studied by everyone interested in up-to-date receiver design and construction. 6/- net.

MODERN RADIO COMMUNICATION VOL. I

By J. H. Reyner, B.Sc. (Hons.), A.C.G.I., D.I.C., A.M.I.E.E., M.Inst.R.E. This work is a model of clear exposition, and throws light on all branches of modern radio theory. With Vol. II (Advanced), now reprinting, it provides a complete course in radio engineering and covers the syllabus of the City and Guilds examinations as well as the P.M.G. Certificate. 7/6 net.

PITMAN, Parker St., Kingsway, London, W.C.2

GRAMOPHONE CABINET AMPLIFIER. TP.533B (RC)

(As illustrated) 30-watts output, incorporating Garrard Automatic Record Changer, is typical of the Trix range. Other models with outputs from 15-30 watts, with or without Automatic Record Changer, are available. Also AC/DC types. Substantial cabinets, in light natural oak finish, afford easy access to valves. All controls are conveniently grouped in a recessed panel on the front.

TRIX
Quality SOUND EQUIPMENT
Details of other models on request.

THE TRIX ELECTRICAL CO., LTD
1-5 MAPLE PLACE · TOTTENHAM COURT ROAD · LONDON, W.1
TELEPHONE: MUSEUM 5817 GRAMS & CABLES: TRIXADIO, WESDO, LONDON

Are you on the Muirhead Mailing List?

If you are interested in any of the following divisions of instrument work, fill in just one more form and send it to us. We will then keep you posted with our developments in your particular field.

Name:

Address to which information is to be sent:

Employed by:

Position held:

DIVISIONS OF INSTRUMENT WORK:

	*
Resistances and Resistance Networks	
Laboratory Condensers and Inductances	
A.C. Bridges and Accessories	
Oscillators, Tuning Forks and Timing Devices	
Dials and Drives	
Switches	
D.C. Testing Equipment	
pH Meters and Equipment for the Chemical Industry	

* *Please indicate in the right-hand column the divisions in which you are interested.*

MUIRHEAD

Muirhead & Company Ltd., Elmers End, Beckenham, Ke...
Telephone: Beckenham 0041-2

FOR OVER 60 YEARS
DESIGNERS AND MAKERS OF PRECISION INSTRUMENTS

C.R.C. 61a

BRAY CERAMIC INSULATORS
for L.F. and H.F. Components: also capacitor dielectrics

made by
GEO. BRAY & CO., LTD. LEEDS, 2
Established 1863 Phone Leeds 20981

Dainite
MOULDED RUBBER SERVICE
Invite inquiries. Advice given on rubber formulas for special requirements.

THE HARBORO RUBBER CO. LTD. MARKET HARBOROUGH

CLASSIFIED ANNOUNCEMENTS

The charge for miscellaneous advertisements on this page is 12 words or less, 4/- and 4d. for every additional word. Box numbers count as four words, plus 1/- extra for replies. Remittance should accompany advertisement. Cheques and P.O.'s payable to Hulton Press, Ltd., 43 Shoe Lane, E.C.4. Replies to box numbers should be addressed as above, marked "Elec. Engg." Press date: 15th of month for following issue.

FOR SALE

IN STOCK. Rectifiers, Accumulator Chargers, Rotary Converters, P.A. Amplifiers, Mikes, Mains Transformers, Speakers of most types, Test Meters, etc. Special Transformers quoted for.—University Radio, Ltd., 22, Lisle Street, London, W.C.2. GER. 4447.

ELECTRIC LIGHT glass multi fittings and a good selection of radio and electrical spares at a low cost. S.A.E. for list to Dioptrical Vision Aerial Co., 17, Mill Hill, Deal, Kent.

SALE. 37 "Electronic Engineering," May 1943 to August 1946 (except May 1946 and January 1944). Offers to Edgar, 64 Lordens Hill, Dinnington, Sheffield.

ROTARY CONVERTERS 12 volt D.C. input, 480 volt 40 m.a. or 460 volt 80 m.a. output, D.C. Brand new and tested, still in original boxes, to clear 17/6 each. Electro-Voice Products, 51, Reeves Avenue, Kingsbury, N.W.9. 'Phone : COLindale 5198.

FOR SALE. 8 Vitavox 4-cell projector speakers fitted car mounting, in perfect condition with 20 watt pots. Will sell separately at £12 each, or £90 the lot. List price £21 each. Box 932, "Elec. Engg."

RELAYS. Unrepeatable offer of new boxed, Post Office type relays, at a fraction of cost price. Type A : coil 500 ohms ; contacts, 1 changeover, 1 make 3s. each. Type B : coil 200 ohms ; with slug, 1 changeover, 1 break, 3s. each. Type C : coil 200 ohms, with slug, 1 changeover, 1 make, 3s. each. Type D : all sold. Type E : two independent windings 500 and 1,000 ohms ; 2 makes, 1 changeover, 4s. each. Type F : coils 500 and 1,000 ohms ; 3 makes, 1 break, 4s. each. Type G : thermal delay unit, 100 ohms ; 1 changeover, 2s. each. Type H : special high sensitivity, coil 10,000 ohms ; 1 adjustable changeover, 6s. each. A few are available with coils as types A, B, or E, and contacts as H, 3s. each. Also with coils as H, and contacts as A, B, E, or F, 6s. each. Send S.A.E. for descriptive leaflet. Minimum order £1 post free. No C.O.D. Box 894, "Elec. Engg."

WESTERN BALL moving coil microphones, unsurpassed for recording and P.A. purposes. Special offer, £20 each. Prompt deliveries Leak "Point One" amplifiers. Fully illustrated technical brochure now available. J. P. Short (Agent), 4, Oakhill Road, East Putney, S.W.15 (Telephone : PUTney 0873).

LOUDSPEAKERS

LOUDSPEAKERS—We carry on. Sinclair Speakers, 12, Pembroke Street, N.1.

LOUDSPEAKER repairs, British, American, any make, moderate prices.—Sinclair Speakers, 12, Pembroke Street, N.1.

MISCELLANEOUS

WE WILL BUY at your price used radios, amplifiers, converters, test meters, motors, pick-ups, speakers, etc., radio and electrical accessories. Write, phone or call, University Radio, Ltd., 22, Lisle Street, London, W.C.2. GER. 4447.

TESTING EQUIPMENT for laboratory and factory designed and manufactured by expert engineers. All types of non-standard equipment for research or mass-production. Free consultations. Gamma Electronics, Ltd., 12 Greenford Road, Greenford, Middlesex. Telephone WAXlow 3152.

COMMUNICATION RECEIVERS, several brand new models in stock including Canadian very high gain model covering 16-500 metres in three bands, A.C. operation B.F.O., R.F., and Radio Gain controls, completely self-contained in grey metal cabinet with speaker and fully guaranteed for one year. These models are in very short supply, price 32 gns. each. We can also supply these complete five waveband communication receivers in black crackle cabinets with separate speaker, 30 gns. U.H.F. communication receivers covering 90-126 m/cs, 12 valve complete with separate speaker, a superb instrument, 45 gns. Several 60 watt. A.C. amplifiers with twin channel mixing from 12 gns. Motor tuned T.R.F. Radio and amplifier, 10 watt output can be operated from any room or manually, 30 gns. Valves, type EF50 with valve holder, 12/- fully guaranteed. International Electronics, 655, Fulham Road, Walham Green, S.W.6. 'Phone : RENown 4178.

WE ARE NOW able to undertake the adjustment of resistors and capacitors over a wide range to within 0.1 per cent. Customers' own apparatus, including audio oscillators and wavemeters, carefully calibrated to any required degree of accuracy. We can supply special precision radio and mechanical components from the small gear or coil to the complete apparatus for the solution of unusual problems. Facilities also available for instrument finishing, including : engraving panels and dials, black crackle enamelling, and silver, nickel or chrome plating instrument parts. Lydiate Ash Laboratories, nr. Bromsgrove, Worcs.

THE NAME TO NOTE for all kinds of radio and electrical metalwork to specification, modern rust-proofing, all shapes and sizes undertaken, and for tropical use. Components and sub assemblies executed to meet recognised wiring and material standards. Consultation, advice without obligation. Write : Department O1, Sea Rescue Equipment Ltd., Chiltern Works, Clarendon Road, Watford, Herts.

WE HAVE THE Largest Stock of English and American radio books in the country, including many now out of print. Write or call for complete list. The Modern Book Co. (Dept. E.E.), 19/23, Praed Street, London, W.C.2 (PAD. 4185).

PHOTOGRAPHY BY BEHR will show your product at its best. Ask for illustrated list. 44, Temple Fortune Lane, London, N.W.11. SPEedwell 4298.

WEBB'S Radio Map of the World enables you to locate any station heard. Size 40 in. by 30 in. 2-colour heavy Art Paper, 4/6, post 6d. Limited supply on Linen, 10/6, post 6d.—Webb's Radio, 14, Soho Street, London, W.1. 'Phone : GERrard 2089.

MORSE Practice Equipment for Class-room or Individual Tuition. Keys, Audio Oscillators for both battery or main operation. Webb's Radio, 14, Soho Street, London, W.1. 'Phone : GERrard 2089.

RADIO AMATEUR CALL BOOK (Winter Edition) 8/9 post paid. Subscription for one year 30/- post paid. Copies are posted direct from America. Orders with payments to authorised distributors : Dale Electronics Ltd., 105 Bolsover Street, London, W.1.

COMPONENTS FOR PROTOTYPES.—Commercial buyers for large industrial organisations, requiring components for prototypes (especially when they are in a hurry—which is mostly always) are gradually finding that the quickest way to get what they want is to 'phone Pad. 6116, or call at 177, Edgware Road (not far from Marble Arch) and take the goods away with them. No matter what is required, if we haven't got it in stock we always do our utmost to get it quickly, and we usually know where—and how.

OUR OWN FACTORY.—We have just acquired additional space on the premises and now have our own factory—primarily engaged on communications apparatus, transmitters and U.H.F. receivers. Mind you, it is only a little factory, but it is surprising sometimes what initiative and determined effort can do. WHEN you have a minute to spare—call in and see us—you will be quite interested.

Tele-Radio (1943), Ltd., 177, Edgware Road, London, W.2 (PAD. 6116).

BERRY'S (SHORT WAVE) LTD., have everything of the latest interest for HAMS and AMATEURS, included in their latest fully-illustrated catalogue "E.E."—6d. post free. 25, High Holborn, London, W.C.1.

SITUATIONS VACANT

A.M.I.E.E., City and Guilds, etc,, on "NO PASS—NO FEE" terms. Over 95 per cent. successes. For full details of modern courses in all branches of Electrical Technology send for our 112-page handbook —FREE and post free. B.I.E.T. (Dept. 337B), 17, Stratford Place, London, W.1.

SUPERINTENDENT of Test Gear Section required by London firm of radio component makers. The responsibility involves design and maintenance of electronic test equipment. Degree or equivalent with industrial experience essential. Salary £500 upwards according to qualifications. Apply Box 899. "Elec. Engg."

JUNIOR ENGINEER required for the laboratory of a London firm of radio component makers. Degree or equivalent essential. Salary £400 upwards according to qualifications. Apply Box 900, "Elec. Engg."

SENIOR ENGINEER required for the laboratory of a London firm of radio component makers. Degree or equivalent with industrial experience essential. Salary £500 upwards according to qualifications. Apply Box 901, "Elec. Engg."

METALLURGIST required to undertake development work into the manufacture and application of tungsten carbide products. University degree preferred and experience in this field essential. Northampton or Swindon districts. Write stating age, experience, qualifications and salary required to Box 895, "Elec. Engg."

PROCESS CHEMIST, with analytical experience and degree or equivalent in chemistry, required to supervise pilot plant production and carry out development work in connection with electronic components. Northampton or Swindon districts. Write stating age, experience, qualifications and salary required to Box 896, "Elec. Engg."

CHEMIST required for development work on new type of cellulose acetate film for acoustic applications. Degree or equivalent in chemistry essential, plus experience of band casting machines. Northampton or Swindon districts. Write stating age, experience, qualifications and salary required to Box 897, "Elec. Engg."

METALLURGIST OR PHYSICIST required for development work on magnetic iron problems ; degree or equivalent essential, plus preferably experience in some branch of powder metallurgy. Northampton or Swindon districts. Write stating age, experience, qualifications and salary required to Box 898, "Elec. Engg."

ELECTRICAL ENGINEER or electronic physicist required, capable of original calculations and design work on electronic equipment, wave propagation problems and similar work. Degree or equivalent and some research or design experience essential. Approximate age 25-30. Salary £400 approx. Apply Staff Officer, British Insulated Callender's Cables Ltd., Erith Works, Belvedere, Kent. Ref. SR. 8.

DESIGNER of Communications Receivers, Transmitters, etc., wanted for small lab. Must be able to work right through on own initiative. Applicants must give full details of practical experience ; state age and salary required. Good prospects. Box 142, Parrs, 121, Kingsway, London, W.C.2.

CHIEF INSPECTOR required for West London works manufacturing audio frequency amplifiers, electronic equipment and precision instruments. Applicants must have previous experience similar capacity, theoretical knowledge equivalent to Higher National Certificate standard radio and electrical sections, and be capable of controlling personnel. Apply, giving full details past experience and salary required, to Box 933, "Elec. Engg."

A FIRM IN LONDON requires communication engineer with considerable experience of radio circuit design especially on aircraft equipment and miniaturisation. Good basic training and subsequent industrial experience essential. Post will be responsible one with very interesting prospects for right man. Initial salary up to £850 per annum. Write full details of education, qualifications and experience to Box 922, "Elec. Engg."

RADIO DEVELOPMENT Engineers for mass production of domestic radio receivers. Minimum technical qualifications being standard of City and Guilds Finals, and for senior -position applicants must have actual factory experience of putting into production laboratory designed models. Apply to Personnel Manager, Airmec Limited, Wadsworth Road, Perivale, Greenford. Other applicants will not be entertained.,

RESEARCH DEPARTMENT of British Insulated Callender's Cables Ltd., require immediately experienced designer for telephone and radio frequency cables accessories. Responsible and progressive post. Applications, giving all particulars, to Staff Officer, Prescot, Lancs.

RADIO ENGINEERS. Large firm in London area requires experienced radio set designers ; previous experience essential. Write stating age, experience and salary required to Box 926, "Elec. Engg."

(Continued on next page)

CLASSIFIED ANNOUNCEMENTS (CONT.)

ENGINEER required by large firm in London area for design and development work on fractional horse power motors. Previous experience essential. A degree in electrical engineering is desirable. Write giving full details of experience and qualifications, also salary required, to Box 925, "Elec. Engg."

SENIOR ASSISTANT to Patent Manager required by long established radio and television manufacturers. Qualifications must include a degree or equivalent and a sound knowledge, both practical and technical, of radio and electronics, with a real interest in technical correspondence and specifications. Salary between £550 and £700 p.a. according to qualifications and experience. Apply, giving necessary particulars, to Box 923, "Elec. Engg."

ASSISTANT required for work in patent department of long-established radio and television manufacturers. Applicant's qualifications must include a good technical knowledge of radio and electronics, preferably a degree or equivalent, a definite aptitude for, and interest in, new inventions, and patent procedure. Salary according to qualifications and experience. Age not above 35 years. Apply, giving necessary particulars to Box 924, "Elec. Engg."

THE BRITISH SCIENTIFIC Instrument Research Association has vacancies in their new laboratories for scientists with first-class academic and professional qualifications. The following appointments will shortly be made in the electrical instruments and electronic departments located in the outskirts of South East London.
(a) Physicist with at least four to five years' experience in electronic instruments or electronic circuits.
(b) Physicist or engineer with at least four to five years' experience in electrical (non-electronic) or magnetic instruments.
(c) Junior physicists or engineers with some experience in the field of electrical or electronic instrument technology. The appointments will be made in the first instance in the Scientific Officer grade: £300-550 and carry F.S.S.U. benefits after a probationary period. Application in writing only giving full details to Director of Research and Secretary, B.S.I.R.A., 26 Russell Square, W.C.1.

SALES MANAGEMENT. A deputy Sales Manager is required by an engineering company near London, manufacturing and selling precision instruments. Essential qualifications are:—(1) Engineering training, experience and qualifications; (2) Experience in controlling a technical sales department and service department operating on a budgetary control basis; (3) Previous personal association with Government technical and production branches; (4) Experience in export procedures and foreign markets; (5) Age, 30-40 years. The initial salary is between £1,000 and £1,500 per annum and subject to satisfactory service, the successful candidate will be eligible for a higher executive appointment. Apply by letter to Box A.C. 14335, Samson Clarks, 57/61, Mortimer Street, London, W.1.

APPLICATIONS are invited for the following appointments in an engineering company manufacturing electro/mechanical precision instruments on a batch basis:—(a) Production Engineer to take charge of a department comprising process engineering, jog and tool design, rate fixing and tool manufacture. Salary grade: £900-£1,200 per annum.
(b) Production Engineer to determine and control production methods (machining and assembly) on small precision electro/mechanical instruments. Salary grade: £650-£850 per annum. (c) Production Engineer to determine and control production methods on precision electrical components (e.g. coils, chokes, transformers, motors, generators, etc.). Salary grade: £750-£1,000 per annum. The company is situated in the London area and employs about 1,500 people. A pension scheme is available, and the above appointments are eligible for participation after 12 months service with the company. Apply by letter to Box A.C. 14334, Samson Clarks, 57/61, Mortimer Street, London, W.1.

RADIO ENGINEER. Large radio firm in London area requires a deputy to the head of its radio laboratory. The engineer concerned should have both theoretical and practical experience, preferably of radio equipment for the services. Write stating age, experience and salary required to Box 931, "Elec. Engg."

WORKSHOP ASSISTANT wanted for research laboratory of radio firm in S.W. London area, for construction of electronic apparatus. Good mechanical and electrical experience essential. Write giving full details of past experience to Box 373, L.P.E., 110 St. Martin's Lane, W.C.2. quoting reference "M.1."

WANTED—ENGINEER with knowledge of electronic circuit design for work in connection with apparatus used on gas turbine engine development. Some mechanical engineering experience an advantage. Box 929, "Elec. Engg."

APPLICATIONS are invited by a firm near London for the position of television engineer. Good up-to-date knowledge of design and development essential. Consideration will be given to a qualified television engineer at present an assistant who has the qualifications to take charge of department. Box 930, "Elec. Engg."

ELECTRONIC ENGINEER required for development work on industrial radio frequency apparatus in connection with machinery and processes for the shoe and allied trades. Candidates must have a good technical education preferably to degree standard and have had experience in the design of radio frequency circuits. Applications should be made to the Manager, Experimental Department, The British United Shoe Machinery Company Limited, Belgrave Road, Leicester

DRAUGHTSMEN. A large North London undertaking require draughtsmen and designer-draughtsmen for their radio department. Workshop experience desirable and preference will be given to men with experience in mechanical design. Write stating age, experience and salary required to Box D. 6737, A.K. Advertising, 212a, Shaftesbury Avenue, London, W.C.2.

ENGINEER to control small test house and establish a development laboratory. Degree or equivalent and some years' industrial experience essential. Must have extensive knowledge of capacitance and inductance as applied to high frequency radio circuits and be capable of directing and supervising. North Western area. State age, experience, qualifications and salary required, to Box 934, "Elec. Engg."

DRAUGHTSMAN required for electronic and electro-mechanical design concerned with instrumentation and plant for high vacuum service. Interesting and progressive post with pension scheme. Applications in writing, giving full details of training, experience, salary expectations, etc., to W. Edwards & Co. (London) Ltd., Kangley Bridge Road, Lower Sydenham, S.E.26.

SITUATIONS WANTED

EXPERIENCED ELECTRONIC, Radio, Television, Research Development and Circuit Designer seeks post with prospects. Fully qualified engineer. First-class references. Box 947, Aldridges, 1, Whitefriars Street, London, E.C.4.

GRADUATE aged 23, General Honours B.Sc., interested in radio, requires opening in this field. Box 928, "Elec. Engg."

WANTED

WE OFFER cash for good modern Communication and all-wave Receivers.—A.C.S. Radio, 44, Widmore Road, Bromley.

INVENTOR seeks financial partner. Those interested please communicate with Box 927, "Elec. Engg."

WANTED, "Electronics and Television and Short-Wave World," Jan., Feb., March, 1940. Box 935, "Elec. Engg."

UNIVERSITY OF MANCHESTER

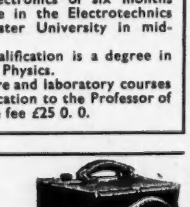
A post-graduate course in High Vacuum Technique and advanced Electronics of six months duration will commence in the Electrotechnics Department of Manchester University in mid-January 1947.

The desired entry qualification is a degree in Electrical Engineering or Physics.

Particulars of the lecture and laboratory courses will be supplied on application to the Professor of Electrotechnics. Course fee £25 0. 0.

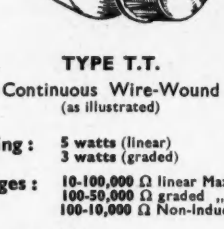
AVIMO

Continuous Film Cameras
For Standard Cathode Ray
Tube Photography



AVIMO LTD., TAUNTON (SOM.)

RELIANCE
POTENTIOMETERS



TYPE T.T.
Continuous Wire-Wound
(as illustrated)

Rating: 5 watts (linear)
3 watts (graded)

Ranges: 10-100,000 Ω linear Max
100-50,000 Ω graded ,,
100-10,000 Ω Non-inductive

Charecteristics:
Linear, tapered, graded, log., semi-log. inverse log., non-inductive, etc.

Write for full details to:

RELIANCE
Manufacturing Co. (Southwark) Ltd.
Sutherland Road, Higham Hill,
Walthamstow, E. 17
Telephone: Larkswood 3245

Partridge News

INDIVIDUAL DESIGN

PARTRIDGE *Precision Built* TRANSFORMERS wound to suit individual requirements now incorporate:—
Silver-plated turret terminals giving a low potential drop and carrying up to 15 amps. Adequate room on each for easy soldering of several external circuit wires.

Firm clamping of the laminations by means of scientifically designed pressure die-castings.

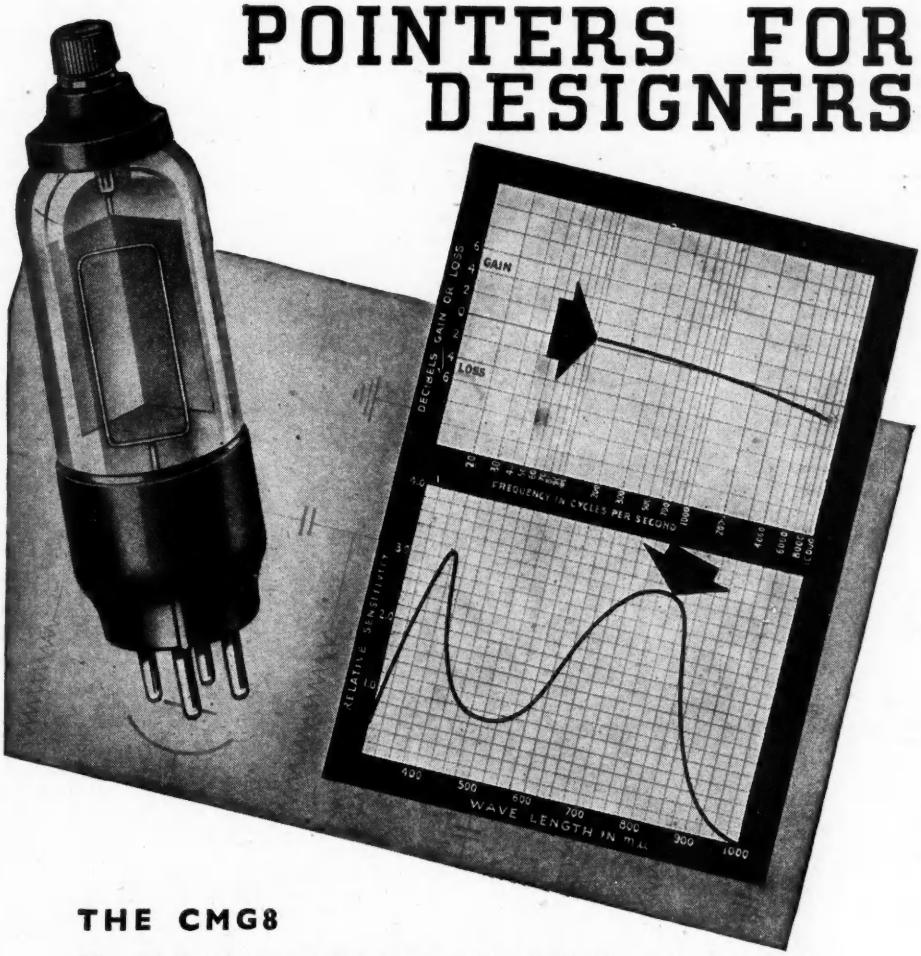
Interlocked fixing feet providing alternative mounting.

AVAILABLE STOCK

A comprehensive range of mains and audio components is now available from stock, and we can despatch small quantities of these per return. We would stress that before ordering you send for our list detailing these components. Our stock range now covers almost all normal requirements, and by availing yourself of this service you will save the inevitable delay in the production of a special component. We shall be pleased to send you our stock list upon receipt of your address.

Telephone: *Abbey 2244*
PARTRIDGE
TRANSFORMERS LTD
76-8, PETTY FRANCE, LONDON, S.W.1.

POINTERS FOR DESIGNERS



THE CMG8

The CMG8 is a typical example of the OSRAM range of emission-type photocells which constitute the essential means of converting light changes into electric current. Widely used in sound projectors and industrial apparatus they are non-microphonic and of convenient size. Outstanding features include :—

- Linear response for sound reproduction giving undistorted output.
- High sensitivity to artificial light.

A detailed technical data sheet is available on request.

Osram PHOTO CELLS — **G.E.C.** CATHODE RAY TUBES — **Osram** VALVES

Advt. of The General Electric Co., Ltd., Magnet House, Kingsway, London, W.C.2.

Components for COMPACT

EDDYSTONE 595, 2 in. dial (direct drive) .. .. **5s. 6d.**
„ **597,** 2 in. dial (precision slow motion) **13s. 6d.**

P.R.S. MIDGETRON VALVES, length 43 m.m.
Type 501, L.F. Pentode, filament 1.4 volts at 50 milliamps.
Type 500, H.F. Pentode, filament 0.75 volts at 50 milliamps.
H.T. volts for both: 45 to 67½ volts. Price, each **£1 4s. 4d.**

"WEARITE" MIDGET INDUCTORS,
shielded in round cans, 1 $\frac{5}{16}$ in. dia., 1 $\frac{7}{16}$ in. high, plus tags.

Type		
207	Mic. or output transformers	Ratio 1/60, 150 m/a on Pri.
210	Ditto	„ 1/15, 75 m/a on Pri.
208	Output transformer ..	„ 8/1, 7 m/a on Pri.
209	Intervalve transformer	„ 1/4·3, 1 m/a on Pri.
212	Modulation transformer	„ 1/1, 15 m/a both.
213	Choke, 40H, 4 m/a, 4,700 ohms.	All types, each **15s. 0d.**

"WEARITE" MIDGET I.F. TRANSFORMERS,
size 1¾ in. by ¾ in., for 460 kc/s, 1.6 mc/s, 4.86 mc/s.
each **10s. 6d.**

T.C.C. "MICROPACK" ELECTROLYTICS

8 mfd. 450 v. 2½ in. by 1 in.	**4s. 6d.**
25 mfd. 50 v. 1 $\frac{5}{16}$ in' by ¾ in.	**3s. 0d.**
25 mfd. 25 v. 1 $\frac{5}{16}$ in. by ½ in.	**2s. 9d.**
50 mfd. 12 v. 1 $\frac{5}{16}$ in. by ½ in.	**2s. 9d.**
.01 mfd. 350 v. 1 in. by ¼ in.	**1s. 0d.**

CELESTION MIDGET LOUDSPEAKER
Outside dimensions, 2½ in square .. .. **£1 7s. 0d.**

EDDYSTONE FLEXIBLE COUPLER,
Type 529 for ¼ in. spindle diameter 1½ in. .. **2s. 6d.**
Type 550 Midget, for $\frac{5}{32}$ in. spindle, dia. $\frac{11}{16}$ in. **2s. 3d.**

VALVEHOLDERS
Hivac Midget Valveholders, 4 and 5 pin, both .. **1s. 0d.**
"Button" ceramic for 6AK5, 9001, V888, etc. **1s. 6d.**
Diode type Valveholder .. .. **1s. 0d.**

We usually stock these items, but this advertisement must not be taken to guarantee immediate availability. Supply continuity still leaves a lot to be desired.

Webb's RADIO

The Short W

14 SOHO ST., OXFORD ST., LONDON, W.1 *'Phone: GERrard 2089.* *Hours of Business: 9 a.m. to 5.30 p.m. Sats. 9 a.m. to 1 p.m.*

Printed in Great Britain by The Press at Coombelands, Ltd., Addlestone, Surrey, for the Proprietors and Publishers, Hulton Press, Ltd., 43-44, Shoe Lane, London, E.C.4. Sole Agents for Australia and New Zealand: Gordon and Gotch (Asia), Ltd. South Africa: Central News Agency, Ltd. Registered for Transmission by Canadian Magazine Post.

6d.
0d.
9d.
9d.
0d.

0d.

6d.
3d.

0d.
6d.
0d.
nent
lity.
red.

m.

E.C.4.